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COMPUTER IMPACT ON TOMORROW'S COAST GUARD

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COMPUTER IMPACT ON TOMORROW'S COAST GUARD

by

Ralph Waverly Judd

LCDR, U. S. Coast Guard

Bachelor of Science
1954
U. S. Coast Guard Academy

A thesis submitted to the faculty of the School of Government,
Business and International Affairs of The George Washington
University in partial satisfaction of the requirements
for the degree of Master of Business Administration

June 7, 1964

Thesis directed by
Karl Ernest Stromsem, Ph.D.
Professor of Business Administration

New occasions teach new duties;
  Time makes ancient good uncouth;
They must upward still, and onward,
  Who would keep abreast of Truth.
                —James Russell Lowell

PREFACE

This report was undertaken primarily to synthesize the various Coast Guard management activities already independently underway but nevertheless related in the computer age. Computer impact may be indirect at times and, where direct, may involve other than Coast Guard computers.

The presentation is from a management viewpoint. Hence, there is no detail about programming any computer and there is only a smattering of mathematics and statistics which may be scanned quickly or omitted with but a small loss in depth of understanding.

No similar report has been made, although some of the material in the chapter on Information Retrieval is taken from a paper previously prepared jointly with CDR Patrick Kennedy USN and LCDR Rex Hoffman USN.

Many Coast Guard Personnel contributed to the study. Among them: CDR Urial H. Leach, Jr., CDR Philip A. Hogue, LCDR David M. Kaetzel, LCDR Ernest E. Rowland, Jr., LT Clyde T. Lusk, Jr., LT John P. Skillings, LT Robert T. Getman, and Ensign John A. Densem. Miss Elizabeth A. Segedi of Coast Guard Headquarter's Public Information Division assisted in obtaining many illustrations. Mrs. Gladys Shimasaki handled the typing chore.

Ralph Judd

Washington, D. C.
June, 1964

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INTRODUCTION

The distinguished scientist, George Gamow, relates in his bestseller, One Two Three...Infinity, "that many (African) Hottentot tribes do not have in their vocabulary the names for numbers larger than three. Ask a native down there how many sons he has or how many enemies he has slain, and if the number is more than three he will answer 'many'."[1] At the Goddard Space Flight Center outside Washington, D. C. there are two 7094 IBM computers which with their predecessors contributed greatly to the success of the Mercury project, with its six manned launchings; these computers determined flight trajectory parameters, the instant position of the spacecraft, future positions of the craft, and acquisition data for all of the sites around the earth. These computers, like most others, can only recognize two numbers or symbols--"0" and "1"--and are called binary digital computers.

This comparison of man and machine suggests that man may be surpassed by the increasingly complex and sophisticated computer. The gap is closing fast and there may one day be thinking machines capable of heuristic problem-solving.

---

[1] George Gamow, One Two Three...Infinity (New York: The Viking Press, Inc., 1947; Published as a Mentor Book by the New American Library of World Literature, Inc., 1953), p. 15.

Tremendous advances have been made in computer technology in the past decade and accelerated growth can be anticipated.

The armed forces of the United States are being directly affected by the development of computer techniques and are themselves contributing to the advancement of computer technology and applications. Computers and computer techniques affect the military in a variety of ways; some of these applications are much the same as those used by business and those employed in education and research. The computer is used by the military for the routine processing of administrative data of all types to facilitate decision-making and record-keeping. The computer is used in Operations Research, in the application of the new management techniques PERT (Program Evaluation Review Technique) and CPM (Critical Path Method), and in the solution of the Information Retrieval problem. Two applications of peculiar significance to the armed forces are in Command Control and Logistics Management.

The purpose of this report is to show computer impact in Coast Guard management areas and what may be expected in the future. To accomplish this study, existing installations of computers were visited to gain information on their functions. Interviews were held with responsible and knowledgeable persons within the Coast Guard who will most likely implement changes wrought by the advance of computers. Applications within other Federal agencies, especially the Navy, were observed and studied with the idea that these uses may forecast Coast Guard utilizations. Current literature in the form of books, public

documents, periodicals, special reports, and some unpublished material was gleaned and perused. The resulting report is unique in that no like effort has been undertaken and this study should be helpful in adding understanding and perspective to the cited and future Coast Guard endeavors, as well as serve as a framework for planning and implementing further management innovations in the computer age.

Chapter I is a quick survey of existing Coast Guard computer installations. Emphasis is placed on the uses being made of each equipment and also the expenses associated with it. Chapters II through VI treat, in order, the subject areas: Command Control, Operations Research, PERT and CPM, Logistics Management, and Information Retrieval. In keeping with the complexity of the computer age, it was found that complete separation by subject was not possible but those which are used represent an optimized division. Most chapters start with a definition of the subject, followed by its development, general applications, and Coast Guard uses and/or anticipated involvement. Chapter VII is a brief summary coupled with some restrained crystal ball gazing. The glossary contains definitions of acronyms and other abbreviations found in the report.

CHAPTER I

EXISTING INSTALLATIONS

Some computers are already in use in the Coast Guard and others are planned. At Coast Guard Headquarters there is an IBM 1410, shown in figure 1. It is located in the ADP (Automatic Data Processing) Division of the Office of the Comptroller. The 1410 is a solid state computer, meaning that it uses transistors instead of vacuum tubes and because of this is also frequently referred to as a "second generation" computer. There are buffers, or storage devices, between the processing unit and the input and output equipment, permitting printing, reading, and processing to occur simultaneously without mutual interference.

The four large magnetic tape drives which are visible in the background of figure 1 provide high speed input and output as well as compact storage. One reel of the tape will store the information otherwise requiring 1/2 million punched cards, which would fill the space of a standard file cabinet. Expansion is possible with this computer by adding additional units, and back-up equipment in case of failure is readily available in Washington, D. C. This computer is also compatible with some others possessed by the Coast Guard and with those in the Treasury Department and in the Navy.

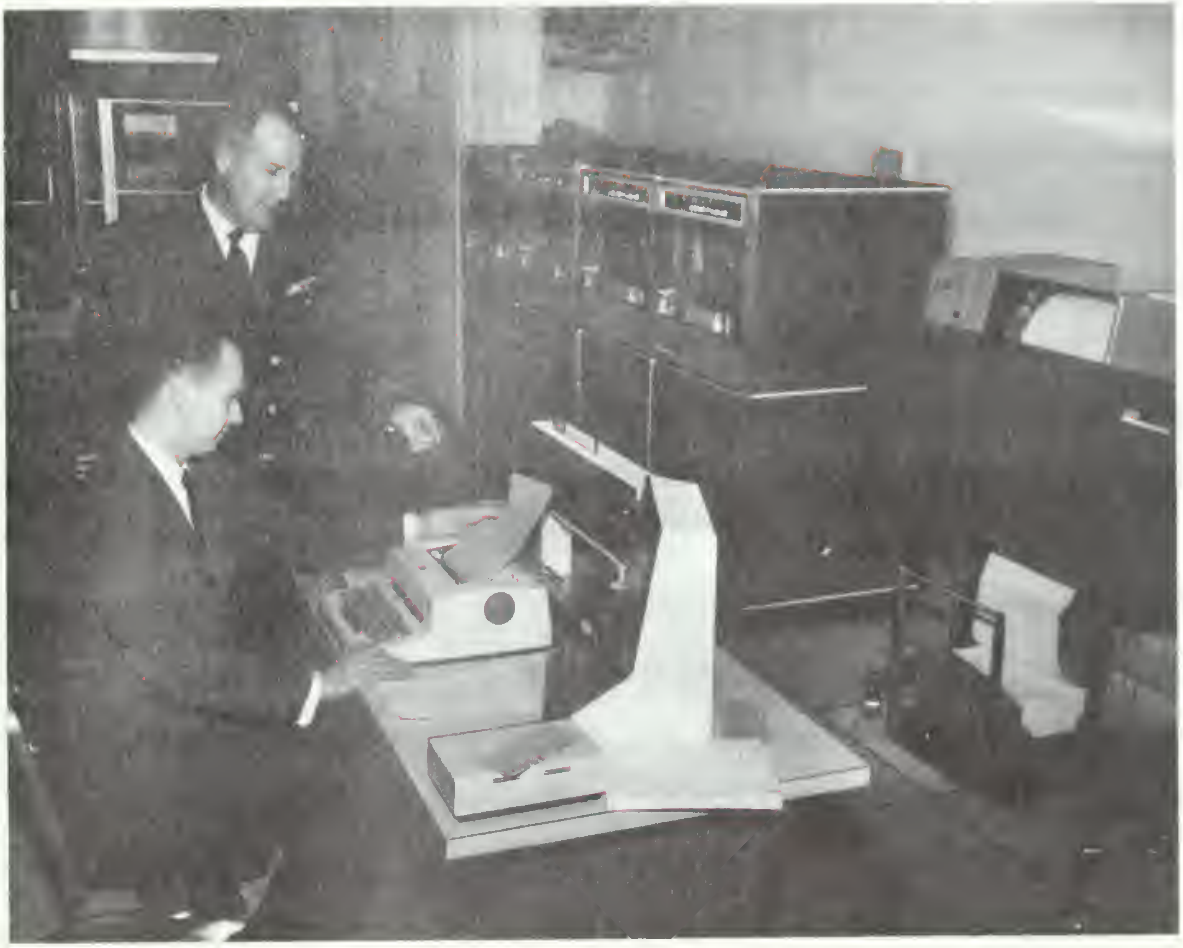

Fig. 1--IBM 1410 at Coast Guard Headquarters

The 1410 is newly installed and replaced a 305 system. Rental expenses increased from $10,000 per month to $13,000. In accordance with the generally recognized objective that new installations should pay for themselves by increased workload and improved efficiency, the additional rental expense has been offset with a decrease in the number of personnel required in the Data Processing Division.

Many applications have been planned for the computer. There will be an integrated Personnel Accounting System in which all regular, reserve (active and inactive), and retired

personnel will be accounted for in a similar system. More data will be contained in individual records and summary records, resulting in improved personnel management. Payroll processing will become more efficient since the speedy magnetic tape processing will allow later changes to be made in each accounting period. One output of the system will be new officer distribution control reports showing vacant billets, distribution by experience, and other information. A timely report will be prepared on enlisted personnel status and will be forwarded to each district, reversing current report procedure. The preparation of electronics inventories and analysis of failure reporting will be accomplished at Headquarters instead of at field units. A consolidated Aids to Navigation inventory will be prepared at Headquarters, as well as various reports connected with Aids to Navigation maintenance. Lastly, all presently executed reports continuing under the new system will be more timely and accurate contributing more to effective management.

Also at Headquarters is an IBM 1620 paper tape system, shown in figure 2. This equipment is used by several divisions in a variety of applications. The Electronics Engineering Division analyzes the power output of Loran C stations to determine that transmissions are within the frequency range assigned. It is also used to calibrate Loran systems and equipment. Merchant Marine Technical Division employs the 1620 for verifying the curves of form of new ships as part of the requirements prior to the issuance of a stability letter to the shipbuilder. Pipe stresses are also studied. The Naval

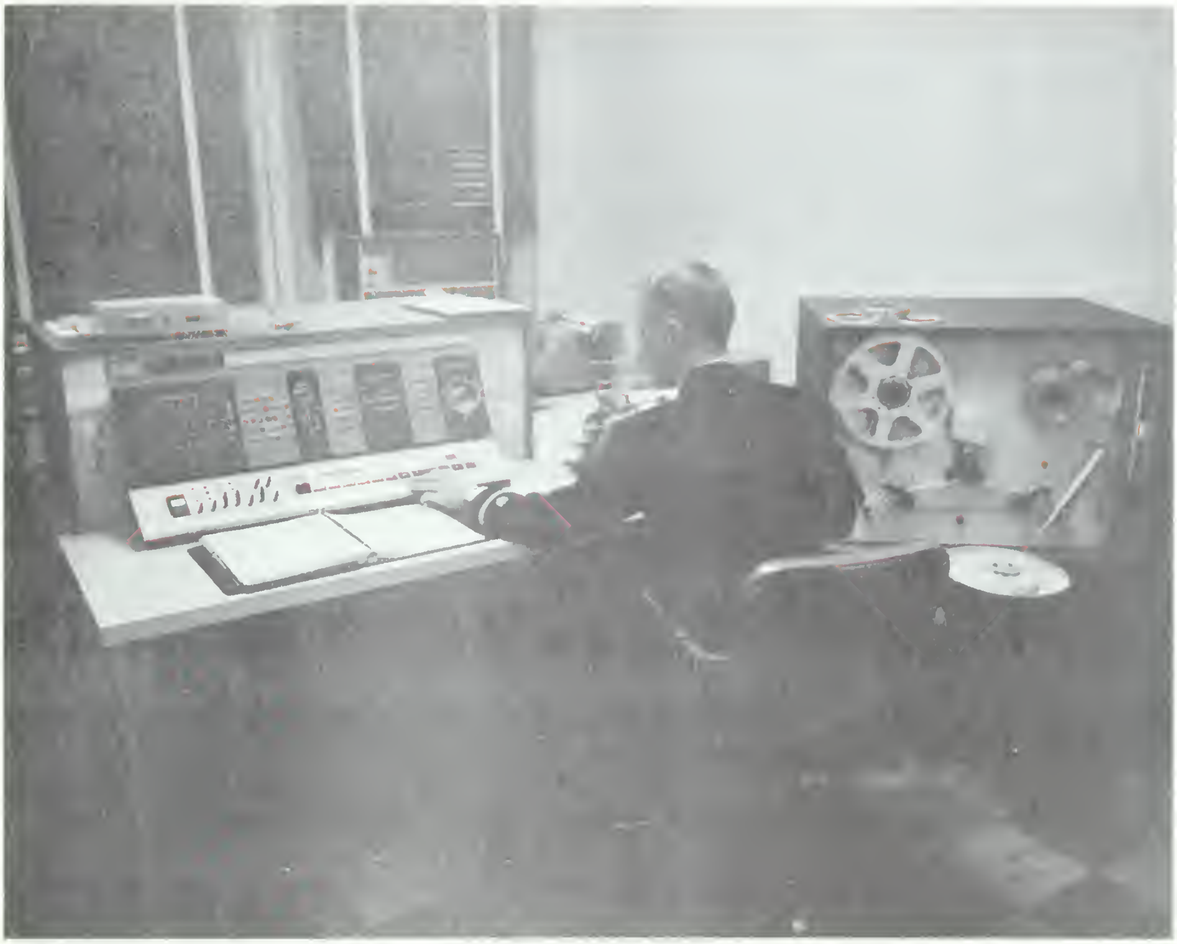

Fig. 2—IBM 1620 at Coast Guard Headquarters

Engineering Division checks out reports on torsional analysis on small boat shafts after the reports are received from a contractor responsible for redesign or new construction. The Aviation Units Division is investigating the correlation between pilot shortage and aircraft accident rate. Leasing costs are $1420 per month.

Another 1620 was recently installed for educational uses at the Coast Guard Academy in New London, Connecticut (figure 3). It differs from the Headquarters 1620 in that the Academy's 1620 employs a card-type system. The computer center

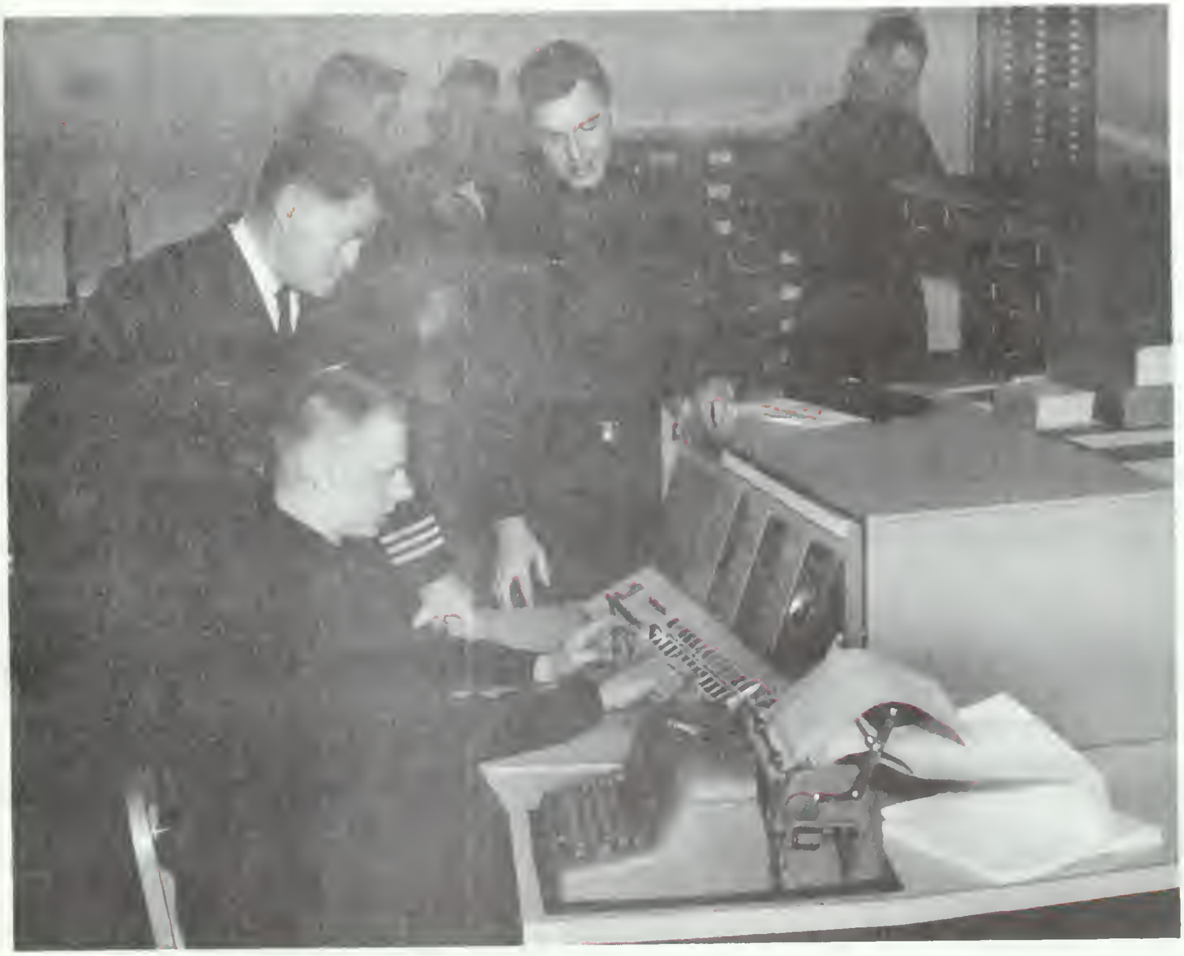

Fig. 3--IBM 1620 at the Coast Guard Academy

is organizationally located directly under the Academic Dean and is available to all departments at the Academy. The system's principal purpose is cadet education in the applications of computers to engineering, science, management, and other disciplines. An important adjunct to this planned utilization has been the response from Academy instructors, area offices, neighboring college faculties, and local industrial leaders when computer courses have been offered at no cost to these groups. Taking advantage of a special 60% educational discount, the Coast Guard purchased the computer for $55,288.

It is the only computer owned outright by the Coast Guard at the present time. Monthly maintenance charges for this installation still total $356.

In Baltimore, Maryland, at the Coast Guard Yard on Curtis Bay, there is located the IBM 1401 system shown in figure 4. Organizationally under the comptroller, it performs a variety of tasks which are primarily of an accounting nature: Payrolling, Stock Item Accounting, Cost Accounting, Stock Class Accounting, General ledger and Subsidiary ledger accounting, Commitment and Obligation Recording, and Project Order Estimating. Eight personnel are assigned to perform the tasks connected with the computer and its associated peripheral equipment. Material cost sheets and weekly cumulative cost reports are provided to the shipbuilders and boatbuilders. Leasing and maintenance expenses for the system total $3,240. per month.

In New York City is an IBM 305 RAMAC (Random Access Method of Accounting and Control), shown in figure 5, which is used by the Eastern Area of the Coast Guard for maintaining the current positions of merchant ships in the Atlantic Ocean, in connection with the program known as AMVER (Atlantic Merchant VEssel Report).

> AMVER is a maritime mutual assistance program which provides important aid to the development and coordination of search and rescue (SAR) efforts in the offshore areas of the North Atlantic Ocean, Caribbean Sea and Gulf of Mexico. . . . Merchant vessels of all nations . . . are encouraged to voluntarily send movement reports to the AMVER Center. . . . Information from these reports is entered into an electronic computer which generates

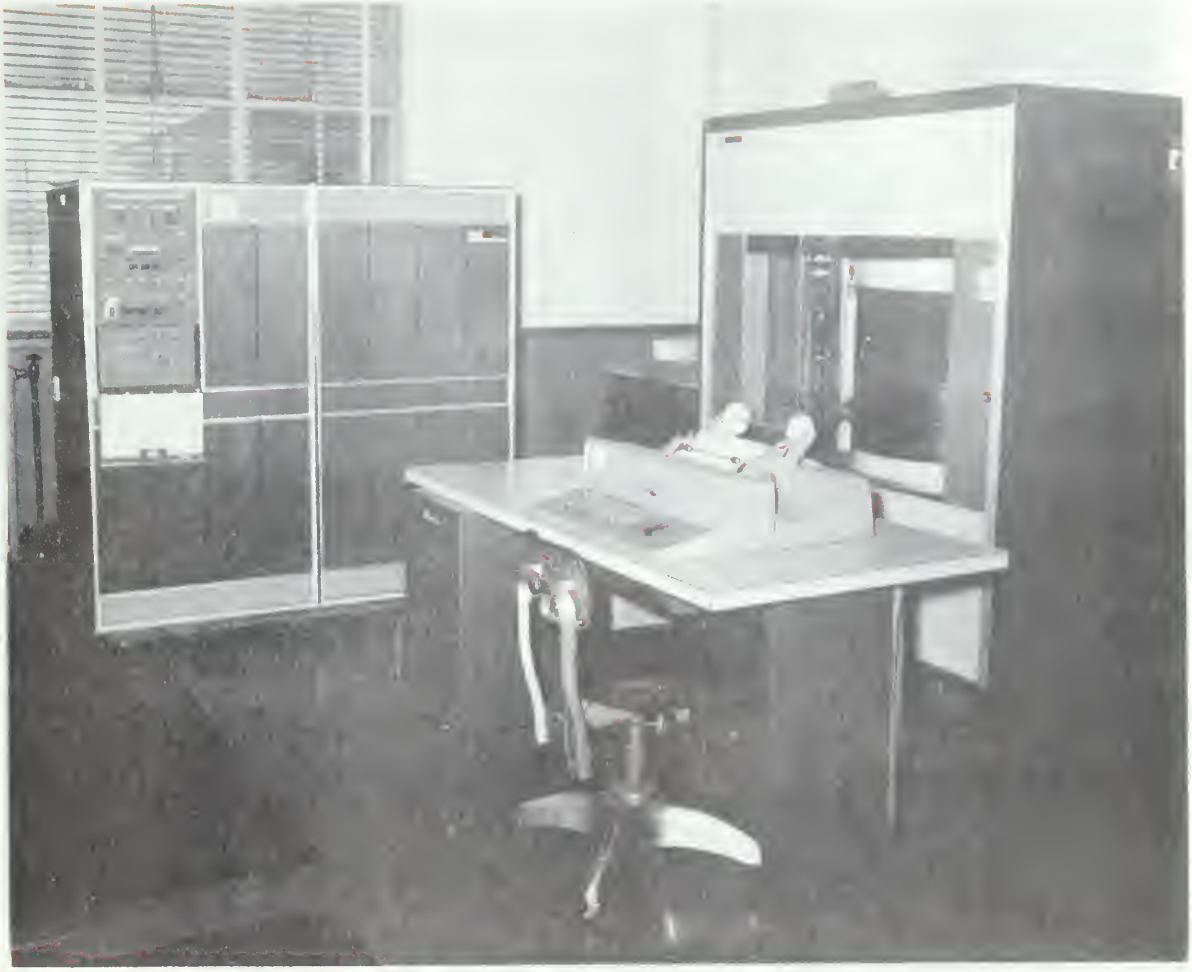

Fig. 4--IBM 1401 at the Coast Guard Yard

> and maintains dead reckoning positions. . . . Appropriate information concerning the predicted location and SAR characteristics of each vessel known to be within the area of interest is made available upon request to recognized SAR agencies of any nation, or persons in distress, for use during an emergency.[1]

The 305 plus associated equipment is leased for $6,230 per month. This computer is scheduled to be replaced by an IBM 1401 system in January, 1965.

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[1] United States Coast Guard, "Atlantic Merchant Vessel Report (AMVER) System," Proceedings of the Merchant Marine Council, Vol. 20, No. 2 (February 1963), p. 35.

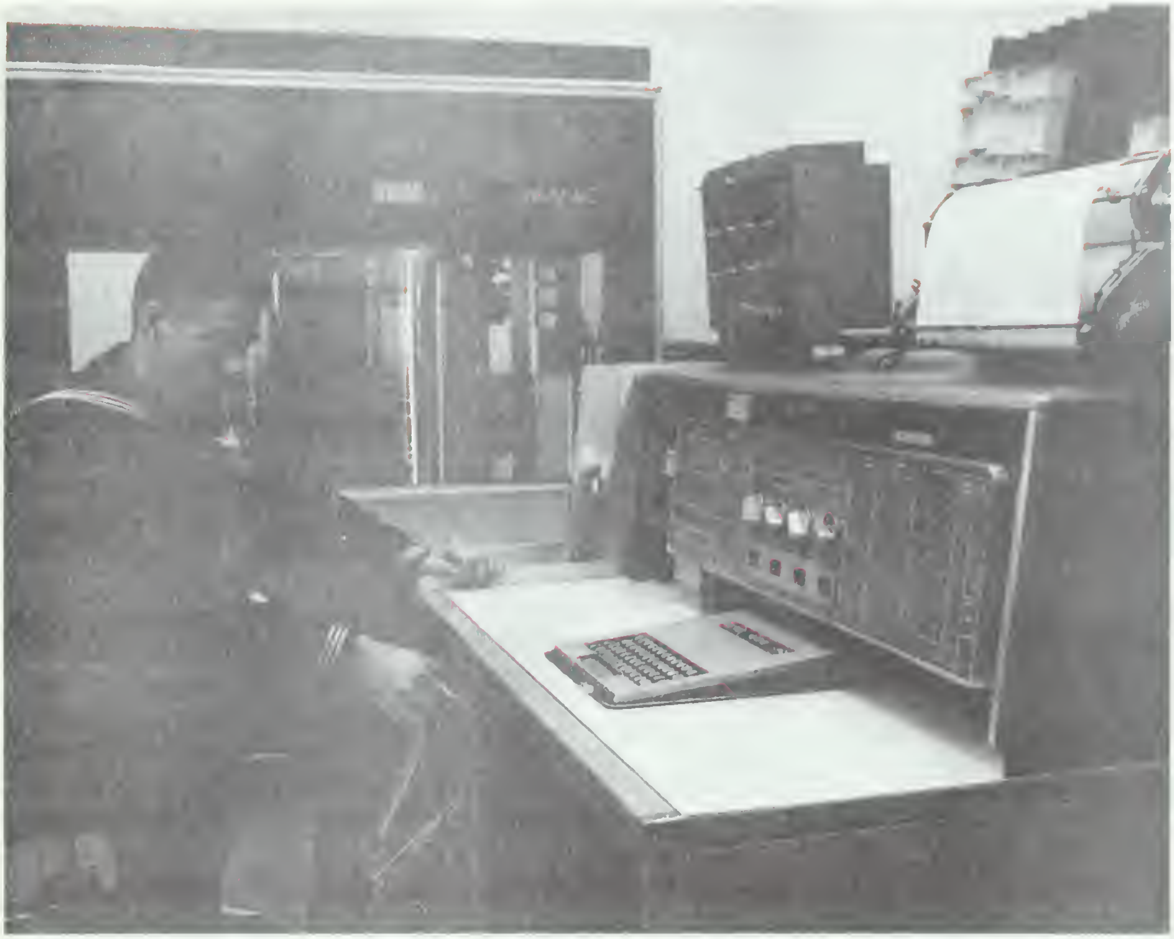

Fig. 5--IBM 305 RAMAC at Eastern Area Headquarters

A survey of Coast Guard hardware would not be complete without including the IBM 403, shown in figure 6. Although not properly called a computer, it is an Electrical Accounting Machine and will be performing the automatic data processing in Coast Guard district offices for the immediate future. Varying in use from district to district, the 403 will be involved in these many activities: Reserve Personnel Accounting, Plant Property Records, Billing and Stores Accounting, District Personnel Locator File, Auxiliary Flotilla Membership Accounting, Reports of Assistance by U. S. Coast Guard

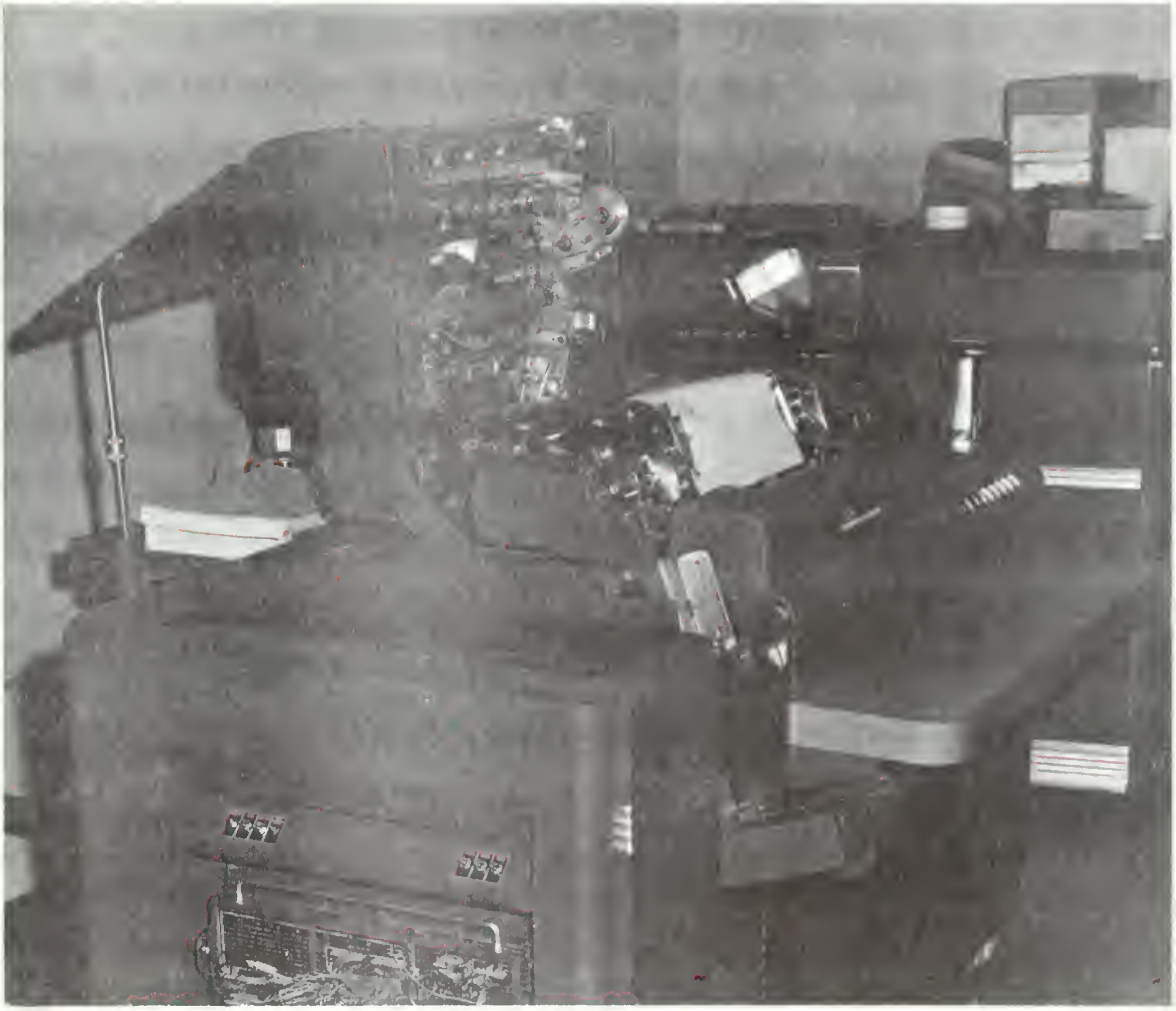

Fig. 6--IBM 403 Electrical Accounting Machine

Auxiliary, FICA Wage Credit and Federal Income Tax Report, Personnel Mobilization, Aids to Navigation Inventory and Industrial Accounting. A standardized format has been stressed for all input and output. This is necessary to achieve efficiency in the supply system for Coast Guard forms and to simplify the development and publication of new and revised applications. Also, many of the punched cards which are output from the district systems will become input to the Headquarters computer system. The 403 and related equipment in each district

office will cost approximately $1000 per month.

Studies are being made by the Coast Guard for further utilization of computers in other Coast Guard applications. At the Aircraft Repair and Supply Base in Elizabeth City, North Carolina, a study is now underway towards defining the data processing requirements with a view toward replacing the present unit record equipment with some type of electronic computer. Aboard the USCGC Evergreen during the 1964 International Ice Patrol season a PDP-5 computer manufactured by the Digital Equipment Corporation of Maynard, Massachusetts will check oceanographic data for validity as soon as the measurements are taken. Without air conditioning or other special protection, the computer will compensate for instrument errors, make necessary calculations, and record all information on a paper tape which will be forwarded to compatible equipment at the National Oceanographic Data Center in Washington, D. C. for further analysis.

This compendium of Coast Guard computer installations reveals the existence and contemplated acquisition of considerable electronic hardware. The days ahead will undoubtedly witness an increasing impact by this equipment in the areas of Command Control, Operations Research, PERT and CPM, Logistics Management, and Information Retrieval.

CHAPTER II

COMMAND CONTROL

Command Control is a "relatively new commonly used expression connoting the means by which the Naval commander controls his forces and weapons, gains and assimilates knowledge of enemy capabilities, and takes into proper consideration factors bearing upon these forces. These factors can include information concerning logistics, weather, communications, intelligence and operations."[1]

The late President Kennedy first sounded the alarm on this subject in a special budget message of March 28, 1961, when he called for "new emphasis on improved Command and Control--more flexible, more selective, more deliberate, better protected and under ultimate civilian authority at all times."[2]

Command Control activities can be subdivided into two large classifications--those systems termed "strategic", which encompass global information and strategy, and those termed "tactical", which relate to the immediate and small area problems. Strategic and tactical have also been differentiated with the language that "strategic" are those matters relating

---

[1] Navy Management Review (June 1963), p. 11.

[2] Ibid., p. 4.

to an entire war while "tactical" are those matters relating to a particular battle. An artist's conception of one of the New Coast Guard 210-ft cutters is shown in figure 7. The deployment of this ship would be strategic; the action of the ship in contact with the enemy would be tactical.

The Navy has established an office responsible for amassing the information related to the strategic aspects of Command Control. It is called the Naval Command Systems Support Activity (NAVCOSSACT). NAVCOSSACT was given the mission to support "the Chief of Naval Operations, Secretary of the Navy, Secretary of Defense, Joint Chiefs of Staff and Commanders of major commands in the development and implementation of Navy sponsored command systems, including systems applications and techniques, standardization, installation, evaluation, testing and computer programming. . . ."[1] NAVCOSSACT, then, is going to be concerned with global strategy and information and must consider politics, economics, shipping, and public opinion as well as military forces. To accomplish its mission, NAVCOSSACT has organized three departments--operations research, systems research, and standardization--and is now completing staff requirements. Within the organization are two separate computer centers in Washington, D. C.

A training development in Command Control has occurred with the establishment of a Department of Defense Computer Institute. Providing orientation and computer comprehension courses, the Institute began its first classes for generals,

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[1] *Ibid.*, p. 11.

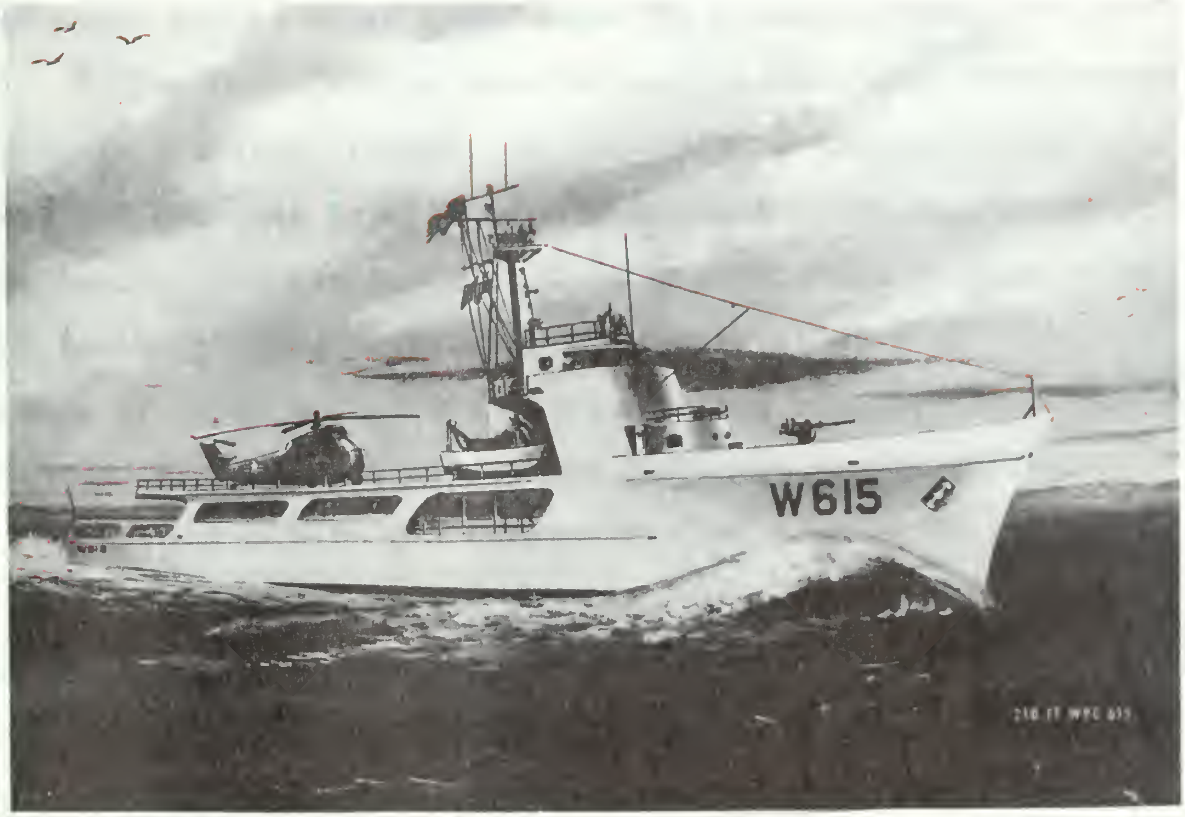

Fig. 7--210 Ft. Cutter

admirals and civilian top management in April 1964. Later courses will be open to Colonels, Captains, and civilian counter-parts.

Still another aspect of the strategic Command Control is war games simulations. Since 1957, the Air Force has had the model called STAGE (Simulation of Total Atomic Global Exchange). The STAGE model is very large, allowing for as many as 25,000 offensive vehicles, 1,000 offensive bases, 1500 defensive bases, and virtually limitless defensive vehicles. Computations involved are accurate and rapid, showing the results and interactions from decisions involving routes, losses of aircraft and weapons, deployment, evacuation policies,

and other matter which would exist in a general war.

The Navy is also involved with a simulator development. Sylvania Electric Products Incorporated was recently given an $875,000 contract to develop a "real world problem generator". The result is going to be a computer-controlled display of an ASW (AntiSubmarine Warfare) operation covering a 500 mile square of ocean area. All surface ships, planes, and submarines will be tracked, controlled, and displayed by the device.

To cope with the Command Control problem of smaller scope--that related to the tactical situation--the Bureau of Ships of the Navy has designed and developed what is called the Navy Tactical Data System (NTDS), which is shown in figure 8. The system is designed for shipboard use, mainly for battle duties but also for routine ship-keeping functions. The total system involves a number of computers and is the logical successor to the Combat Information Center (CIC). Elements of a typical NTD System include the sensors which may be radars or sonars, computers to store and manipulate the data, output display equipment which may combine printing machines with scopes, and the necessary communication links. The accent is on speed and accuracy not only with regard to orders from higher authority but also with regard to action following the acquisition of the contact. Accuracy in tracking has been greatly increased and the "dead time" between target acquisition and attack has been reduced.

New approaches will be made in the development and installation of the NTD and other systems. Active and passive

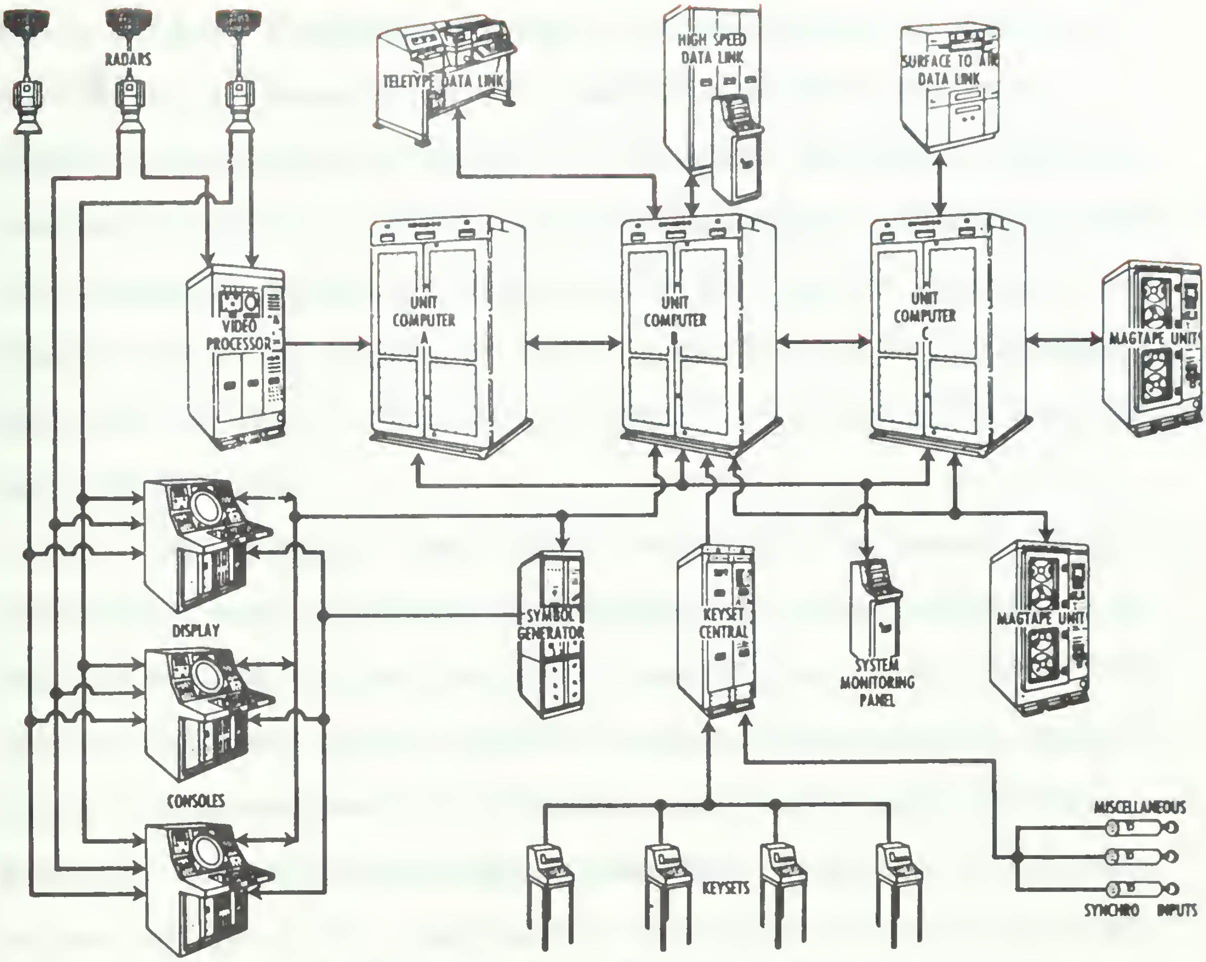

Fig. 8--Typical Navy Tactical Data System

sensors which in the past have been added to a ship in piecemeal fashion will be integrated in the future with all shipboard systems. Operation of this equipment will be kept simple and repairs will be kept to a minimum and will be made as easy as possible.

> Troubleshooting will be done by the machines themselves. The repairman's task will be relatively simple, and he merely will have to carry out the instructions generated by the machine after it has located its own trouble.[1]

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[1] Admiral William F. Raborn, "New Horizons of Naval Research and Development," U. S. Naval Institute Proceedings (January 1963), p. 44.

There will be increased emphasis on modular construction of electronic systems which will permit quicker repairs by module substitution instead of the usual component location and replacement. Already, on the new Polaris submarines such as the Lafayette employing the Mark 84 fire control system, the entire system is contained in a 23 by 21 by 6 1/2 foot compartment and is made of "building blocks" to facilitate installation and maintenance.

The computer has great flexibility in Command Control. Integrated into shipboard organization, it can control very complex weapon systems and other operations. The variations in its programs appear infinite, suggesting that the applications of the computer in military operations are limitless. However, the point has been raised that although flexibility is the source of the computer's strength, it can also be the source of weakness. Nothing can be done by the computer that has not been designed into its program.

> If we consider a computer-controlled, independent combat unit, we wonder what genius will be able to provide the machine with a program designed in advance to meet all conceivable combat conditions. Imagine, for example, a robot combat unit attacked by an unconventional weapon (say a human torpedo) after damage has already incapacitated part of the directing computer itself. The program would have to be flexible indeed to deal with the situation. Yet any human commanding officer would be able to take some sort of improvised action, in this or even less likely circumstances.[1]

But there may be a solution for this problem, also. It would

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[1] Frederic G. Withington, "The Outcome of the Electronic Revolution in the Navy," U. S. Naval Institute Proceedings (November 1963), p. 69.

appear that small arms fire is in order and no computer has been designed yet to direct such fire. However, the Navy has issued a contract recently to the Philco Corporation to study a method of controlling machines by amplifying the electrical signal generated when the brain tells a muscle to move. The size of this signal is usually about 100 microvolts. The idea is to use devices attached to the skin to pick up the pattern, amplify it, and use it to control mechanical devices which could include rifles and machine guns. Along this same line the Sperry Gyroscope Company has already patented a "bio-operated" system for controlling a space vehicle during takeoff and reentry when the astronaut cannot move because gravity forces are so great. So a solution may be forthcoming for the unexpected and unlikely appearance of a human torpedo. The next step would be to substitute a device similar to an optical scanner for the shipboard man involved, yielding a completely robot combat unit.

Also in the area of tactical Command Control, attention is being given to two new navigation techniques designed to pinpoint the position of ships at sea in all kinds of weather. One system involves satellites orbitting the earth; the transmitter station, being built in Minnesota, will receive data from a computing center and pass it on to the navigational satellites when they pass near the station. The satellites will store this data, which are predictions of the satellites's positions throughout their orbits and later the satellites will transmit the information to the ships at sea so they may

pinpoint their positions. This system will be useful to all mariners, since the only equipment required will be a radio and a clock. Presently, however, the computer problem of correction due to satellite velocity and altitude variation are significantly delaying practical use of this type of navigation.

The second system of navigation, called "doppler sonar navigation", involves the transmission of very accurate sonar beams from beneath a ship in four different directions simultaneously; the beams are reflected back from the bottom of the sea or bay. By means of the echoes received, a computer unit on board the ship will plot continuously the position of the vessel on a navigation chart. This system is of especial interest to the Coast Guard because of its potential applications in the areas of Oceanography and Aids to Navigation.

Another area of Command Control which is receiving increasing attention is the automation of merchant vessels. Concern is twofold, since not only is it likely that many of the features of these ships will become standard equipment on cutters but also the Coast Guard is charged with responsibility for maritime safety. In February, 1963, the Commandant said:

> The Coast Guard is aware of the mounting interest in the possible automation of merchant ships.
>
> To assist in the gathering of meaningful, factual data upon which reasonable predictions may be made of the impact of automation, we are furnishing to the Shipboard Mechanization and Manpower Committee of the National Academy of Science all information available from our records.
>
> Being the principal agency concerned with maritime safety, we will, of course, keep current with developments

> in this field so that reasonable and adequate standards of safety may be maintained.[1]

The launchings of the Mormacargo in January, 1964, and the Mormacvega in March, 1964, ushered in the era of the push-button ship. Notable characteristics of the ships include: pilot house control of the engines; quick-acting hydraulic hatches for hold covers; electronics equipment to display at control panels the existing temperatures in refrigerated compartments; automatic control of boilers; electric winches to automatically maintain constant tension on mooring lines; an engine room electronically operated by two men at a central control panel.

These accomplishments are only the beginning steps in the march toward automation.

> On the drawing boards now--for use by 1970--are such things as gas turbines, which would eliminate the need for boilers and burners now used in a steam plant and cut manpower requirements even further.
>
> The computer also is forging into shipbuilding plans. The Norden division of United Aircraft Corp. is now testing the use of a "course computer" on an ocean freighter. It's designed to compute a bearing between one point and another as much as 1,000 miles away and give a constant stream of information on course, speed, and estimated time of arrival. The device--only 12 inches high, 22 inches wide and 15 inches deep--would take over many of the functions now performed by men on the bridge.[2]

Other nations moving rapidly toward automated merchant marines

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[1] Admiral E. J. Roland, "A View and Review of Maritime Safety," Proceedings of the Merchant Marine Council (February 1963), p. 25.

[2] John D. Williams, "U. S. Flag Lines Turn to Automation in Effort to Become Competitive," The Wall Street Journal (March 25, 1964), p. 1.

with such ships already in operation are Japan, West Germany, and Norway.

Sponsored jointly by the Ship Research Institute of Norway and the Division of Automatic Control at the Technical University of Norway, a report entitled "Computer Applications on Board Merchant Ships" has been prepared by Leif B. Solsnaes.

> A survey is given of possible digital computer applications for supervision, control and various data processing purposes on board merchant ships. The major motivation for introduction of a computer in this field is to gain greater returns of ships in terms of safer operation of propulsion system, safer conductance of ship and better economy of sailing and ship operation.
>
> All computer applications are assumed to be performed on time-sharing basis by one centrally located computer, and all programs are assumed to be prepared in advance.
>
> The computer procedures in connection with continuous supervision and control are assumed to be executed completely automatically, while the procedures that are called on by the operator may involve manual selection of programs and entry of data.[1]

The central computer together with some of its inputs and outputs is shown in figure 9. Some of the major findings resulting from this study are abstracted and presented in the succeeding paragraphs.

At the present time there are many mathematical problems solved by personnel on the bridge in connection with the navigation of a ship. The computer could be connected to the radar and an arbitrary closest point of approach for contacts indicated. When another ship is computed to pass

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[1] Leif B. Solsnaes, Computer Applications on Board Merchant Ships (Trondheim: June 1963), p. V.

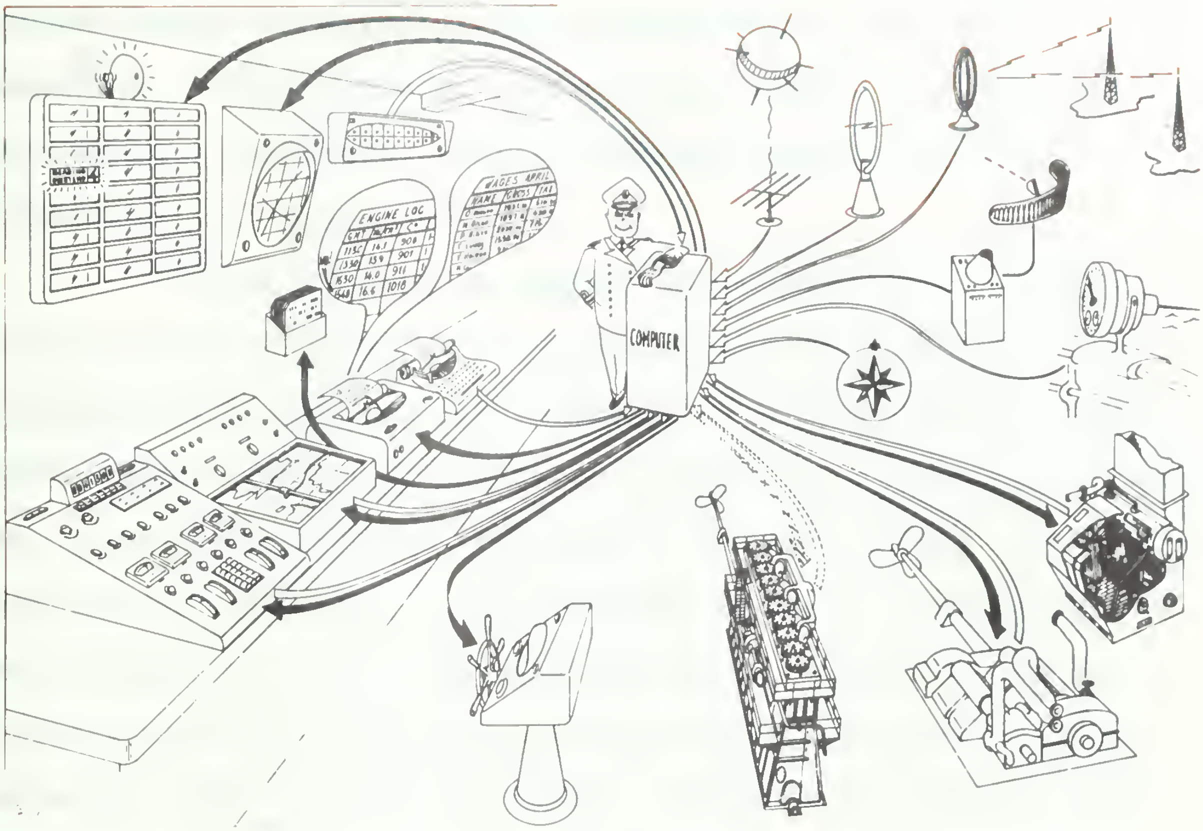

Fig. 9--Shipboard Central Computer

within that distance, data could be fed to alarms, displays and recorders. Outputs of Decca, Loran and similar aids to navigation could be transformed by the computer and automatically plotted. Continuous input from the speed log and gyrocompass could result in a continuous dead reckoning position updated with each new fix. The computer could accurately and rapidly process celestial data yielding lines of position free from the approximations inherent with manual methods. Data now stored in tables could be stored in the computer or computed when needed. The computer could be used to compare the actual route with the preprogrammed route. Steering information to

automatically correct for wind and current could be fed to the autopilot. Most of these navigational chores are presently performed by officers, and the computer would increase efficiency as well as safety.

Weather routing is another area where the processing of much data could be efficiently done by the computer. The procedure involves the determination of a "least time track" from weather forecasts and ship's speed, as a function of ocean and weather conditions. In addition to the benefit of minimum sailing time, there are the secondary gains in less cargo and hull damage as well as increased passenger comfort. Weather chart information could be entered into the computer through automatic curve reading equipment. Other information to be used would be ship's speed, wave height and direction, fuel price, efficiency of propulsion system, hull and propeller deterioration, cargo characteristics, and depth, trim, and stability data. The output of the computer would be the optimum route.

There are a number of computer applications that might be possible in the ship's engineroom. The computer might be used in data logging and processing and in this connection would collect data for legal uses, breakdown studies, improved operations, propulsion system efficiencies, fuel flow calculations, hull deterioration studies, and design analysis. Contributions to safe operation could be made by automatic monitoring of engine room activities, stopping equipment when off-normal situations are detected, and periodic testing of

spare equipment. Control applications such as control of turbine-boiler systems on steam turbine ships are also engineroom uses for a computer that could be designed into a ship.

On deck the computer could calculate cargo distributions, could monitor stresses in the hull, and could handle the accounting necessary in connection with the cargo, payroll, and consumables.

Whether the consideration is strategical or tactical, whether the Command Control involves one ship or many, the modern solution to the ancient problem is going to involve computers. Speed and accuracy in the communication loop are desirable in peacetime and are mandatory during an emergency. The battle for New Orleans was fought days after the War of 1812 had ended. Such a lapse in communications regarding Command and Control is unthinkable now. When the late President Kennedy recommended new command posts and communications centers, he pointed out that these were only the beginning of a major "effort to achieve a truly unified, nationwide, indestructible system to assure high-level command, communications and control, and a properly authorized response under any conditions."[1]

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[1] Navy Management Review (June 1963), p. 4.

CHAPTER III

OPERATIONS RESEARCH

Since Operations Research is still in the development stage, no definition satisfactory to everyone has yet evolved. However, there is general agreement that Operations Research (OR) is the use of the scientific method applied to operational problems to provide quantified alternatives for management decision. The technique leans heavily on logical analysis and quantitative methodology. Obviously an important aspect of the endeavor is the scientific method.

> Very briefly, the scientific method consists of seven basic steps: (1) observation and general survey of the problem area, (2) definition of the problem, (3) fact finding, (4) analysis of the data and construction of a model, (5) comparison of the model with observed data, (6) repetition of above steps until a satisfactory model is constructed, and (7) use of the model to forecast.[1]

The model is usually a mathematical model and so is most frequently an equation or formula.

The OR approach to problems includes the following features: (1) emphasis is placed on the whole-istic approach in that all elements related to the problem area under study are considered, (2) OR is adaptable to any organization,

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[1] Clifford J. Craft and David B. Hertz, "Management Research," Systems and Procedures, ed. Victor Lazzaro (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1959), p. 406.

(3) the study is undertaken by a team of specialists representing economics, science, engineering, or any other disciplines that might assist in the problem analysis, (4) objectives and limitations are included in the study.

OR has found application to a variety of basic types of problems. Allocation problems involve the different combinations of resources that are possible to produce different combinations of products. Inventory problems deal with minimizing inventory costs and hence are concerned with a number of variables: production run sizes, customer loss, quantity purchasing and material shortages. Replacement problems are concerned with balancing costs between buying new equipment and using old equipment with decreasing efficiency and increasing maintenance costs. Waiting-time problems involve the costs and inefficiencies inherent where lines must form and wait to receive a service: supermarket customers, cars at service stations, busses at terminals, hospital patients, and many others. Competitive problems frequently employ "game" models and deal with situations where an executive's decisions must consider the actions of competitors such as a decision to lower the price on a product.

> All of the above situations involve a balancing of two or more conflicting or competing factors. The problem is to develop a strategy that maximizes results as measured by such objective criteria as profits, costs, output, and time. The prototype models that have been developed can be helpful in a number of directions. Some of them . . . can be adapted to actual planning problems with modifications. Inventory and allocation models have been more useful in this respect than have the other types. Models can also be used to train executives and operations

> research specialists. They help define the nature of the planning problem even when they cannot be directly used to solve it. For example, competitive or "game" models give the neophyte insights that may be helpful in solving strategy problems.[1]

To accomplish the required measurement and analysis, a number of procedures, techniques and theories have been developed. The following are some of these approaches to the OR problems: probability theory, sampling theory, queuing (waiting line) theory, linear programming, marginal analysis, total system costing, flow process analysis, matrix of variables, dynamic programming, simulation, and network theory. A successful solution will probably involve the use of one or more of these tools.

Although OR had its beginnings around World War II, its extremely extensive and successful development followed in the wake of computer technology progress. High-speed electronic data processing provides rapid solutions to complex mathematical problems that in the past could not be solved in time for the information to be of value to management. The cost of computer processing is also inexpensive compared to alternative methods and so more quantitative intricacies can be programmed into solutions with a small additional outlay of time and money.

OR concentrates on long-range planning and has been applied in many industries including: chemical, electrical, machinery, food, metals, utilities, and transportation companies. Areas of application, in addition to long-range planning, have

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[1] Henry H. Albers, Organized Executive Action: Decision-Making, Communication, and Leadership (New York: John Wiley & Sons, Inc., 1961), p. 214.

been production, sales and marketing, inventory control, advertising, personnel, and purchasing. Achievements resulting from OR will most likely be evident in three categories: (1) immediate alternatives offered in a particular problem, (2) improved methodologies for future operations, and (3) more knowledgeable management.

Successful applications of OR have not been limited to industry. The Department of the Air Force reports substantial progress with its war gaming models.

> During the past 10 or 12 years there has been an increasing requirement for estimates of the effects of various decisions on the outcome of a general war. These decisions involve, among many other factors, the planning of missile and manned bomber mixes and deployments, base hardening or evacuation policies, weapon stockpile configurations, the use of decoys and other aids to minimize losses of aircraft and weapons, and the selection of aircraft routes and target bombing systems. On these and numerous other questions, alternative courses of action are weighed against each other in terms of their effects on the air battle.
>
> The use of the computer has permitted the human players to focus their attention on the details of planning the offensive strikes and interpreting the results. By using the computer in its proper role, a wide range of situations can be examined and analyses made in very little more time than previously required to make a single examination. The net result of these war games has enabled the Air Force to improve their planning for the future environment by selecting better courses of action among a multitude of variables, which are constantly changing.[1]

The Coast Guard has recently become involved in Operations Research. The Secretary of the Treasury, the

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[1] U. S., Congress, House, Committee on Post Office and Civil Service, Use of Electronic Data Processing Equipment in the Federal Government, 88th Cong., 1st Sess., 1963, H. Rept. 858, pp. 62, 64.

Honorable Douglas Dillon, wrote in the forward to U. S. Coast Guard a study of its origin, responsibilities, relationships, and direction:

> Ever since assuming my duties as Secretary of the Treasury in January 1961, I have been concerned about the critical problem facing the United States Coast Guard because of the obsolescence of much of its equipment and facilities. A review of long-range requirements for vessels, shore stations, and aircraft indicated a need for a phased program of capital expenditures totaling more than $1 billion in order to provide adequate operating tools for the men of the Coast Guard.
>
> I concluded that a comprehensive study of the Coast Guard's roles and missions, together with a review of existing policy and operational guidelines, would be helpful in deciding our course of action. Accordingly, a study of the Coast Guard's 10 major missions was begun by an inter-agency group composed of experts from the Bureau of the Budget, the Department of Defense and the Treasury Department. This study, lasting 8 months, was concluded in June 1962, and resulted in 80 recommendations. I have now directed that action be taken on 76 of them.[1]

One of the recommendations which resulted from the roles and missions study was this:

> An operations research study be conducted for use by the Coast Guard in developing a coordinated long-range plan for total mission accomplishment as a logical operational planning step.[2]

Out of this recommendation grew a report entitled The Application of Operations Research to Management and Planning Problems of The United States Coast Guard. It was compiled by a commercial firm called Management Technology, Inc. and was prepared

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[1] U. S., Treasury Department, U. S. Coast Guard a study of its origin, responsibilities, relationships, and direction, 1963, p. 1.

[2] Management Technology, Inc., The Application of Operations Research to Management and Planning Problems of the United States Coast Guard (Washington: By the author, 1963), p. I-1.

for the Chief of the Commerce and Finance Division of the Bureau of the Budget.

The report is preliminary in nature in that it is not the result of application of OR but merely studies the possibility of OR application and makes recommendations. The study first considered background information. The objectives of the Coast Guard were categorized into two major groupings--those mission oriented and those long range planning oriented. The ten missions to accomplish the objectives were delineated: Search and Rescue, Aids to Navigation, Law Enforcement, Military Readiness, Merchant Marine Safety, Reserve Training, Oceanography, Icebreaking, Ocean Stations, and Port Security. Coast Guard resources, some of which are shown in figure 10, were determined to be: vessels, boats, aircraft, and other major equipment; officer, enlisted and civilian manpower; shore facilities; command and control systems; and funds. The organization by districts, the measures of performance to determine levels of effectiveness, and recent growth demands on existing resources were also noted as being significant factors affecting the study.

The approach to the study included interviews with Coast Guard Personnel at Coast Guard Headquarters, Eastern Area offices, Third Coast Guard District offices, Sandy Hook Life Boat Station, Base St. George, and the Brooklyn Supply Center. More data was acquired from these units by collecting copies of reports, forms, and previous studies. Potential problem areas were identified in this manner and added to the problems which

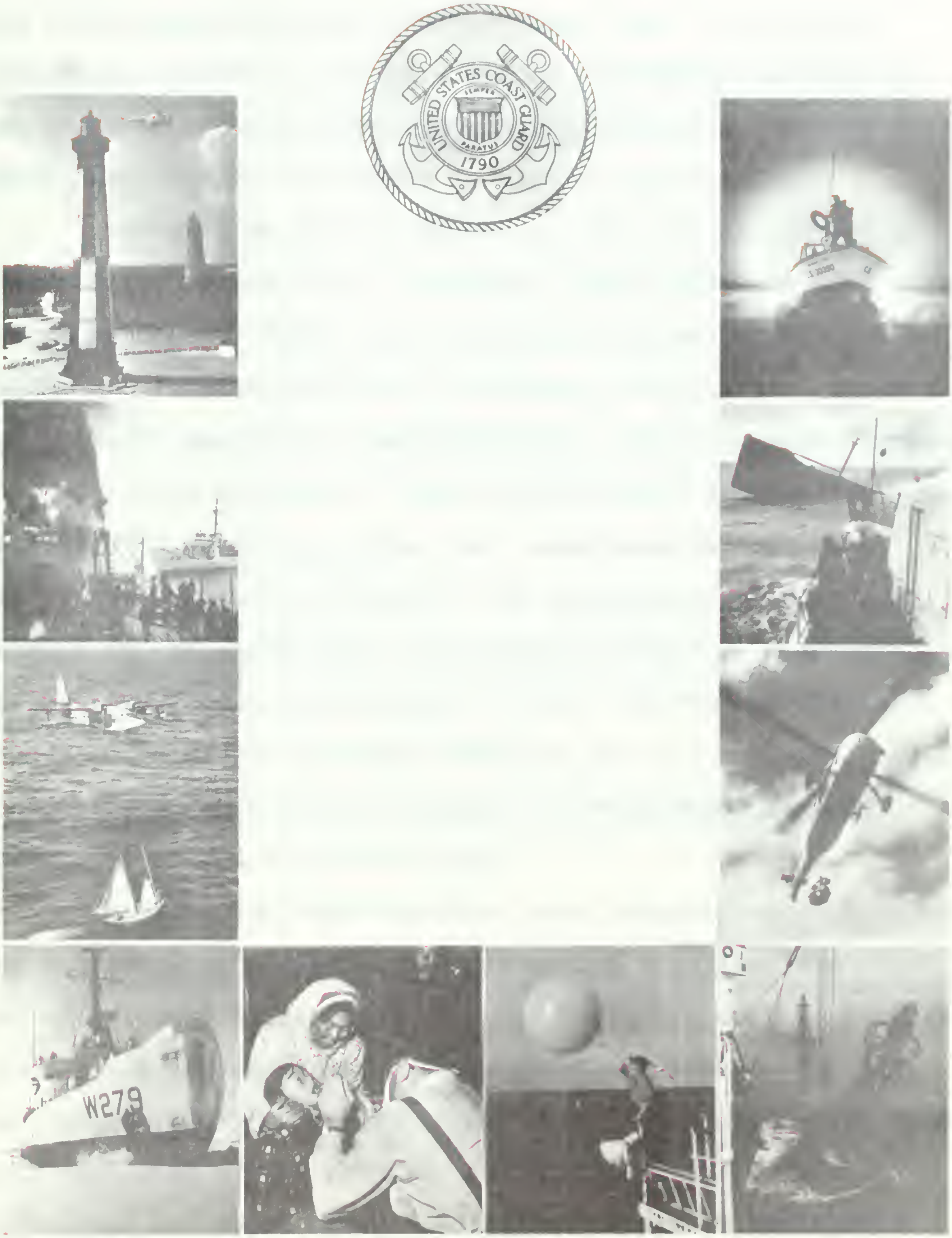

Fig. 10--Some Coast Guard Resources

had become apparent from previous Coast Guard and Treasury Department studies. The third method of hunting for problems was to examine Coast Guard operations, keeping in mind OR tools which had a record of success in similar applications.

The outcome of this survey was the identification of eighty-eight problems of a management and planning nature within the Coast Guard. These were grouped by the ten mission categories and four newly-created management categories: Command and Control, Logistics, Administration, and Long Range Planning.

In the analysis of these eighty-eight problems to select potential OR projects, three basic requirements were used: (1) Projects should provide for the development of the Coast Guard's own OR capability, (2) Projects should be meaningful--having significant potentiality for the improved utilization of resources and/or services rendered, and (3) Projects should contribute to an improved planning and management control capability within the Coast Guard.

Finally, definite criteria were established to control the selection of projects: (1) potential benefits from decreased costs and/or increased services, (2) cost to conduct project and implement and operate resulting system, (3) time lag between project completion and realized benefits, (4) success potential of the project, (5) extent of the problem throughout the Coast Guard, and (6) avoidance of duplication between OR projects and extant endeavors.

From these efforts the following twenty-five potential OR projects were identified:

SEARCH AND RESCUE PROJECTS (4)

MISSION AND RESPONSE TIMES FOR SEARCH AND RESCUE OPERATIONS: To determine mission and response times for such operations using existing criteria and data and develop a method for reducing these time spans, thereby improving effectiveness.

PLEASURE BOAT INCIDENTS: To determine the expected number of pleasure boat incidents relative to the geographic location and physical density of these vessels.

SEARCH TECHNOLOGY DEVELOPMENT: To develop improved concepts of search technology and to determine cost-effectiveness benefits.

SEARCH AND RESCUE TRAINING: To develop a system for measuring performance in search and rescue exercises and relate exercise performance to expected level of mission accomplishment.

OCEANOGRAPHY PROJECTS (1)

OCEANOGRAPHIC RESEARCH: To determine the parameters of the Coast Guard's own oceanographic programs in both cost and effectiveness terms as this effort relates to the nation's over-all Oceanographic Research Program.

MILITARY READINESS PROJECTS (1)

MILITARY OPERATIONAL CAPABILITY: To determine the military operational capability of the Coast Guard for military actions which might occur in the 1965-75 decade.

LAW ENFORCEMENT PROJECTS (1)

RESOURCES ALLOCATION: To develop performance standards and to determine the optimal allocation of law enforcement resources based upon these standards.

AIDS TO NAVIGATION PROJECTS (1)

SPACE AIDS TO NAVIGATION: To analyze the future impact of space aids to navigation on maritime operations and measure the benefits anticipated in both cost and operational terms.

MERCHANT MARINE SAFETY PROJECTS (4)

MERCHANT VESSEL TRAFFIC CONTROL SYSTEM: To determine the advisability and feasibility of merchant vessel traffic control in harbors and their approaches.

MERCHANT MARINE SAFETY PROJECTS (Cont.)

COMMERCIAL FISHING VESSELS REPORTING SYSTEM: To determine the feasibility and practicality of developing and implementing a commercial fishing vessel reporting system similar to the merchant vessel reporting system (AMVER).

DANGEROUS CARGO OPERATIONS: To develop a system utilizing automatic data processing equipment and capable of being up-dated which will compare the cost of alternative methods of cargo handling and storage with the relative costs of potential disasters.

COMMERCIAL FISHING VESSEL AND DIESEL TUG REGULATION: To determine the feasibility and cost of extending merchant vessel marine safety regulations to commercial fishing vessels and diesel tugs and to determine the cost-effectiveness benefits to the Coast Guard and to commercial firms.

ICE BREAKING PROJECTS (1)

ECONOMIC BENEFIT OF ICE BREAKING: To develop a method that will determine and measure the economic impact and benefits to be derived by the shipping industry from ice breaking activities of the Coast Guard.

COMMAND AND CONTROL PROJECTS (1)

INTEGRATED MANAGEMENT INFORMATION SYSTEM: To develop a management information system that satisfies in an optimal manner information requirements and reduces data volume to a useable level.

LOGISTICS PROJECTS (2)

LOGISTICS MANAGEMENT SYSTEM: To develop an improved logistics system for the economic ordering and inventory control of required supplies.

AIRCRAFT MAINTENANCE SUPPORT: To determine the level of aircraft maintenance and logistics support required to attain prescribed operational levels.

ADMINISTRATION PROBLEMS (2)

MULTI-AGENCY INSPECTIONS: To develop a method for the integration of multiple inspection services performed by public and private organizations on numerous aspects of the Merchant Marine, with a view to the attainment of an economic and effective consolidated inspections program.

ADMINISTRATIVE PROBLEMS (Cont.)

MERCHANT CREW RECORDS MAINTENANCE SYSTEM: To develop an improved system of merchant crew records handling and determine the cost-effectiveness benefits that would result from this improved method.

LONG RANGE PLANNING PROJECTS (7)

LONG RANGE PLANNING SYSTEM: To develop a system model suitable for use in solving long range planning problems in the Coast Guard.

PERSONNEL UTILIZATION PROGRAM: To develop an improved method for determining personnel training and assignments with such needs serving as a guide for recruitment and career planning.

EVALUATION OF MEDICAL SERVICES: To study the existing method of providing medical services and to determine whether an improved pattern of service--considering the number and location of personnel covered--can be developed.

REQUIREMENTS PLANNING FOR MAJOR RESOURCES: To improve current methods for requirements determination. Through an analytical OR evaluation of needs, develop methods for total requirements programming with adequate cost justification.

AIRCRAFT UTILIZATION: To develop criteria for the most effective utilization of aircraft in a number of mission areas with particular reference to over-all mission requirements and anticipated technological changes in equipment.

COAST GUARD RESEARCH AND DEVELOPMENT CAPABILITY: To determine the cost and effectiveness benefits that might be obtained from a Coast Guard research and development program of a comprehensive mission-supporting nature.

OBSOLESCENCE OF MAJOR RESOURCES: To develop a method of anticipating the obsolescence of major resources with consideration given to the determining of adequate cost-effectiveness justifications.[1]

From this list of twenty-five projects the study went on to select four which appeared to be most suitable for an

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[1] Management Technology, Inc., The Application of Operations Research to Management and Planning Problems of the United States Coast Guard (Washington: By the author, 1963), pp. VI-5 to VI-10.

initial program of Coast Guard Operations Research: (1) A Long Range Planning System, (2) Major Resources Replacement Policy, (3) Personnel Utilization System, and (4) Multi-Agency Inspections Study. Further detail was then presented about these four projects including information on objectives, procedures, and benefits.

A close look at the relationship between missions and resources resulted in the chart in figure 11. Management must properly slice the resource cake to be consumed by the missions and do it successfully year after year. The division is not as neat and orderly as suggested by the chart and the desired balance among the three components is hard to come by. Consideration was given to the environment within which Coast Guard planners must function. Seasonal workloads complicate the already recognized problem of increasing demands for Coast Guard Services. Technological advancement constitutes a two-edged sword which lessens the demand for Coast Guard services in some areas such as commercial plane ditchings and at the same time quickens the pace of obsolescence of Coast Guard equipment. Thus, the environment of the Coast Guard planner is both complex and ever changing.

Against this background Management Technology Inc. considered the four initial OR projects. The first proposal encompassed the establishment of a long range planning system on which progress was recommended step by step: (1) System Design and Description, (2) Pilot Application to one Coast Guard District, and (3) Implementation of the Total System.

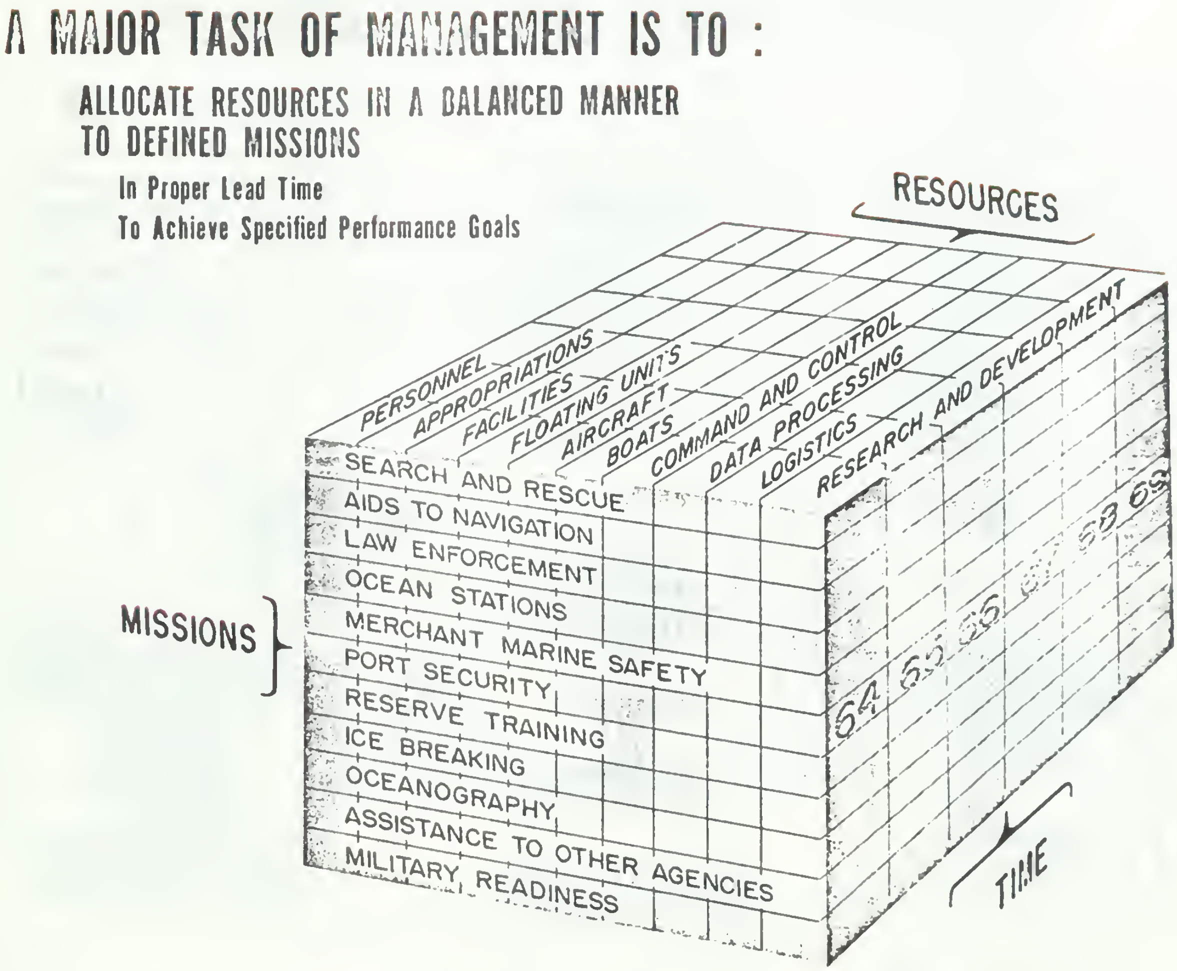

Fig. 11--Missions and Resources Related in Time

The long range planning system in operation is shown in figure 12. Simulation of a small portion of the "real world" would be accomplished by programming a computer with all appropriate information related to a Coast Guard District's operations. Various new suggestions in alternative form could then be tested in this model to determine effects which might result with the actual implementation of the changes in the "real" Coast Guard.

The study of the major resources replacement policy is another of the initial projects, and the procedure would be:

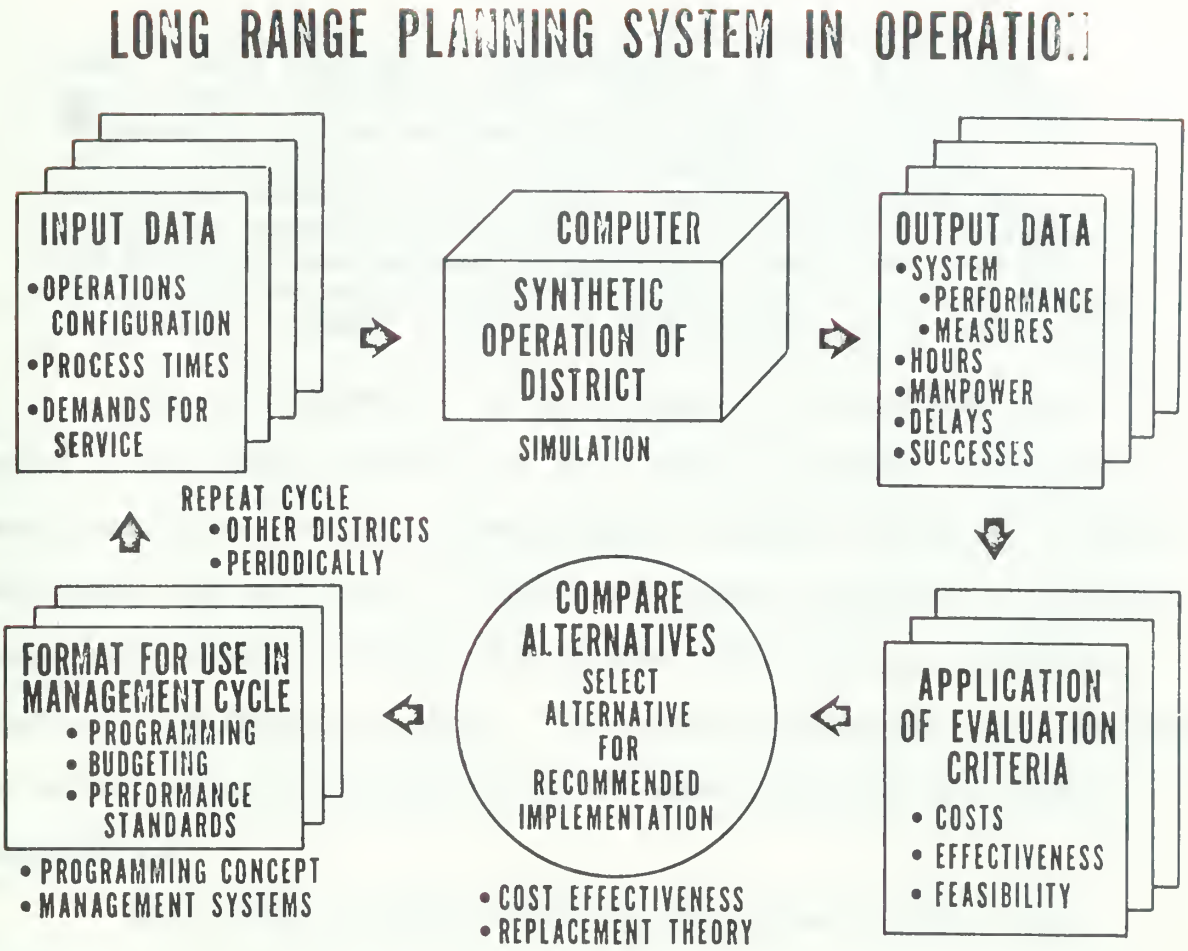

Fig. 12

(1) data collection, (2) model building, (3) data analysis, and (4) formulation of an optimal solution. A total cost approach to the problem is contemplated, and factors involved in the proposed model would include: cost of operation of maintenance for and investment in a given vessel, probability of saving vessel and cargo by Coast Guard vessels of specified capability, value of vessel and cargo saved, total vessels in Coast Guard fleet, salvage value of CG vessels retired during the planning period, and total years in the planning period. The result of this study would be substantial.

> The benefits to be derived from this proposed model would include a determination as to the total system costs for different replacement policies; the assessment of the desirability of adding vessels with new capabilities to the Coast Guard's fleet; the potential reduction in fleet size made possible by increased vessel capabilities; the cost to be anticipated for keeping obsolescent equipment in service; and the basing of new requirements requests more on a return-on-investment concept than on a serviceable life concept.[1]

The establishment of a personnel utilization system would be the third project in the initial program. Subjects of study would be: billet forecasting, relative sizes of officer, enlisted, and civilian CG manpower, career planning, projected personnel costs, reenlistment trends with reasons, potential tradeoffs in manpower types. The resultant benefit contemplated is improved decision-making due to more accurate and timely information.

The fourth project would be the study of the many agencies and the inspections they conduct in connection with the many phases of the shipping industry. Involved are fourteen agencies of the Federal government as well as eight private organizations. The result would be a combination and reduction of these many activities associated with the extensive group of agencies. Money would undoubtedly be saved not only because of a reduction in inspection personnel required but also by freeing vessels for more profitable utilization.

From this study by Management Technology Inc. of the application of OR to the Coast Guard there have already evolved

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[1] Ibid., p. VII-10.

significant consequences. The report has been approved in principle by the Bureau of the Budget, the Treasury Department, and the Coast Guard. A Planning and Operations Branch has been established in the Program Analysis Division of Coast Guard Headquarters. Several of the projects have already begun and $250,000 has been included in the 1965 budget to cover the cost of technical assistance required for the recommended initial four projects. The Coast Guard has undertaken Operations Research in a substantial manner, anticipating success with increased efficiency and economy resulting from improved management.

Other investigations of smaller magnitude in the area of Operations Research are being conducted by other organizational units in Coast Guard Headquarters. The Flight Safety Branch of the Aviation Units Division in the Office of Operations is conducting a study to determine if a relationship exists between pilot shortages and the rate of aircraft accidents. Preliminary results are shown in the graph of figure 13. Known data for past years is used to determine three plots: pilot shortages versus time, accidents versus time, and accident rate versus time.

From the plots it would appear that there is a close relationship between the shortage of pilots and the rate of aircraft accidents. With the data for both curves for nine years a coefficient of linear correlation has been calculated with the 1620 computer at Headquarters. The number of pilots for the coming year is well known and so the machine can use

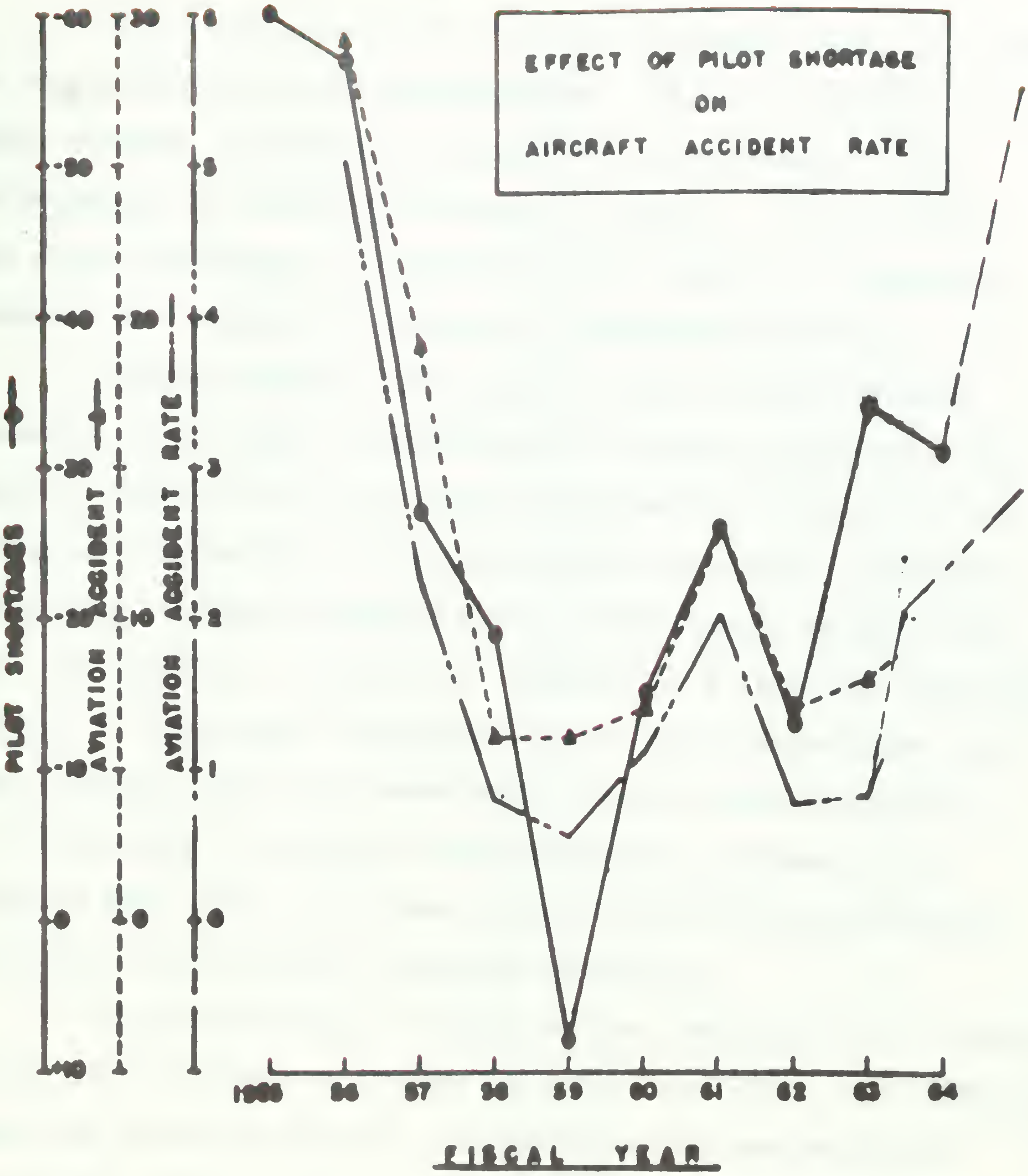

Fig. 13

this quantity with the coefficient to iterate (trial and error procedure) until the corresponding number of accidents or accident rate is found. This new-found rate is, of course, a prediction for the coming year.

Also, the assumption is being considered that there may be non-linearity in the relationship. In this connection the Least Squares technique is being used to determine if the relationship is possibly quadratic or cubic. In any event, the study represents a significant step forward in improved planning and control by the use of Operations Research.

Another project employing the 1620 is the Spectrum Analysis of the power transmissions of Loran C stations. The Loran C Branch of the Electronics Engineering Division of the Office of Engineering receives data from the Loran C station Commanding Officers relating power and frequency outputs for each transmitter. The data is obtained by a sampling technique and can be considered representative of all transmissions that have emanated from the transmitter for the specified period. It is important to analyze this information because it is required that 99% of all power transmitted from each station lie within a designated frequency bandwidth.

The distribution of power versus frequency for a sample set of data is shown in figure 14. The band width is indicated along the abscissa and it is required by the International Telegraphic Union, under international agreement, that the shaded area contain 99% of the power and hence represent 99% of the area under the curve. This problem is quickly solved using Simpson's rule and the 1620. In this example, .158% lay below the band, 1.071% lay above and so 98.771% is within the band. This spectrum analysis of Loran C transmissions represents yet another successful Coast Guard application of

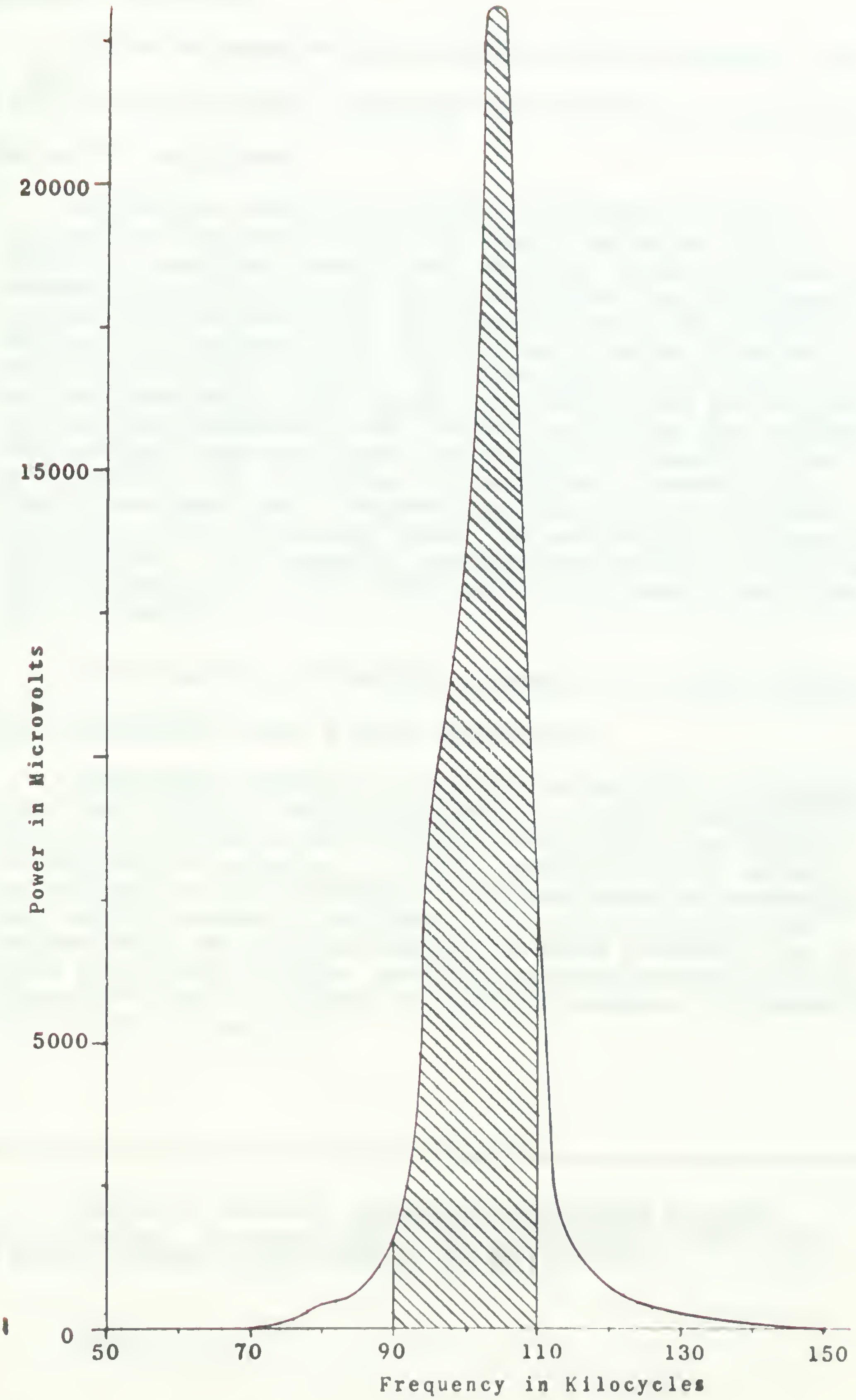

Fig. 14--Power Distribution of Loran C Transmissions

Operations Research.

OR holds considerable promise for the future, but there are also some problems involving uncertainties which will not yield to OR techniques.

> Executives should be wary of attempts to make operations research sound as though miracles were somehow possible through the magic of higher mathematics. Mathematical techniques can facilitate the solution of empirical problems only if there is some relationship between the dynamics of the phenomena being studied and mathematical logic. The formulation of restrictive assumptions about the nature of reality has the effect of leaving unanswered the "solutions" that are assumed. The assumptions that have to be made in constructing some models are sometimes the critical elements in a decisional problem. Emphasis should be given to the idea that many problems cannot be solved by mathematical techniques. For example, probability theory is not useful in solving many of the uncertainty problems that face the executive.[1]

The already considerable success of OR has led some of its proponents to be overly optimistic.

> Operations research, like the scientific management that went before, will undoubtedly be more successful in solving decisional problems that relate to things as opposed to people. It will provide better answers to production and inventory problems than to personnel and market research problems. It will increase the objectivity of decision-making in some measure, but it will not eliminate the need for subjective techniques. Executives will continue to provide answers to questions that have no answer.[2]

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[1] Henry H. Albers, Organized Executive Action: Decision-Making, Communication, and Leadership (New York: John Wiley & Sons, Inc., 1961), p. 217.

[2] Ibid., p. 218.

CHAPTER IV

PERT AND CPM

"Plan your work and work your plan" is an old adage popular with contract bridge enthusiasts. It is also suggestive of a modern management tool--PERT. The word PERT is an acronym derived from "Program Evaluation Review Technique". PERT assists the manager to plan and control the use of resources in achieving established goals. It involves some mathematics, which makes it a statistical technique, and when these statistics become complicated enough, a computer is desirable to process the data.

PERT was originally developed to utilize time more efficiently in the accomplishment of programmed objectives. Subsequently, as the utilization of funds became a significant factor, a variation of PERT was developed called PERT Cost. PERT had its beginning around 1958, but a year prior to this, there began to be employed in the construction industry a technique called the Critical Path Method (CPM) which bears a clear and close resemblance to PERT. Consideration will be given to these three tools separately, beginning with PERT.

> PERT is a statistical technique. It cannot make decisions. It only provides a basis for decision making. PERT quantifies knowledge about uncertainties faced by the activities responsible for meeting a predetermined time schedule. The very process of analyzing these uncertainties focuses management's

> attention on the critical areas. When these are pinpointed management can decide what corrective actions are necessary.
>
> PERT . . . uses networks to show time and dependency relationships between the factors contributing to developing a system, project, or task. Just as a production line must have its materials and parts scheduled to arrive in the required quantity, at the right place, and proper time to assemble a finished product so all subsystems must mesh properly. . . .
>
> Through PERT data, management can evaluate (a) possible "trade-offs" in time and (b) analyze the value of redistributing resources in order to improve the chances of meeting time schedules. This statistical technique can quickly give the results of alternate courses of action, so that there is a choice of decisions available.[1]

The following problem is similar to a network development exercise which is used in a course presented at the PERT Orientation and Training Center at Bolling Air Force Base in Washington, D. C. The situation involved is as follows. A speech is to be made to an invited audience who are to receive an outline of the presentation with their formal invitations. RSVP's are requested and the conference room where the speech will take place must have the minimum number of chairs specially arranged to avoid overcrowding and discomfort. Below is a random listing of probable events which will occur prior to the established goal:

1. Dry run presented
2. Chairs arranged
3. Presentation delivered
4. Invitations prepared

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[1] Program Evaluation Review Technique (Wright-Patterson Air Force Base, Ohio: Management Research and Procedures Aeronautical Systems Division, 1964), p. 1.

5. Presentation revised
6. Room reserved
7. Speech prepared
8. Mail list prepared
9. Outline prepared
10. Replies received
11. Invitations mailed
12. Name cards prepared

A PERT network is shown in figure 15 which begins with "Go Ahead" and ends with "Presentation Delivered". This network is a diagram of a plan consisting of events and activities. Events are not timeconsuming but are rather a moment of time and on initial PERT networks were represented by circles although now they are sometimes represented by rectangles. Activities separate events; activities are timeconsuming usually and are represented by an arrow. The arrow indicates the activity taking place between two events. Sometimes the activity does not consume time; in the example, the arrow between "Outline Prepared" and "Invitations Mailed" indicates a "constraint". That means that while "Outline Prepared" must precede "Invitations Mailed", there is no time consumed between the two events. In early PERT networks, "constraint" arrows were dotted; however, this practice is not followed currently in most cases.

The locations of the event circles on the network are not significant although it is customary to have the earlier events to the left and the end objective on the right.

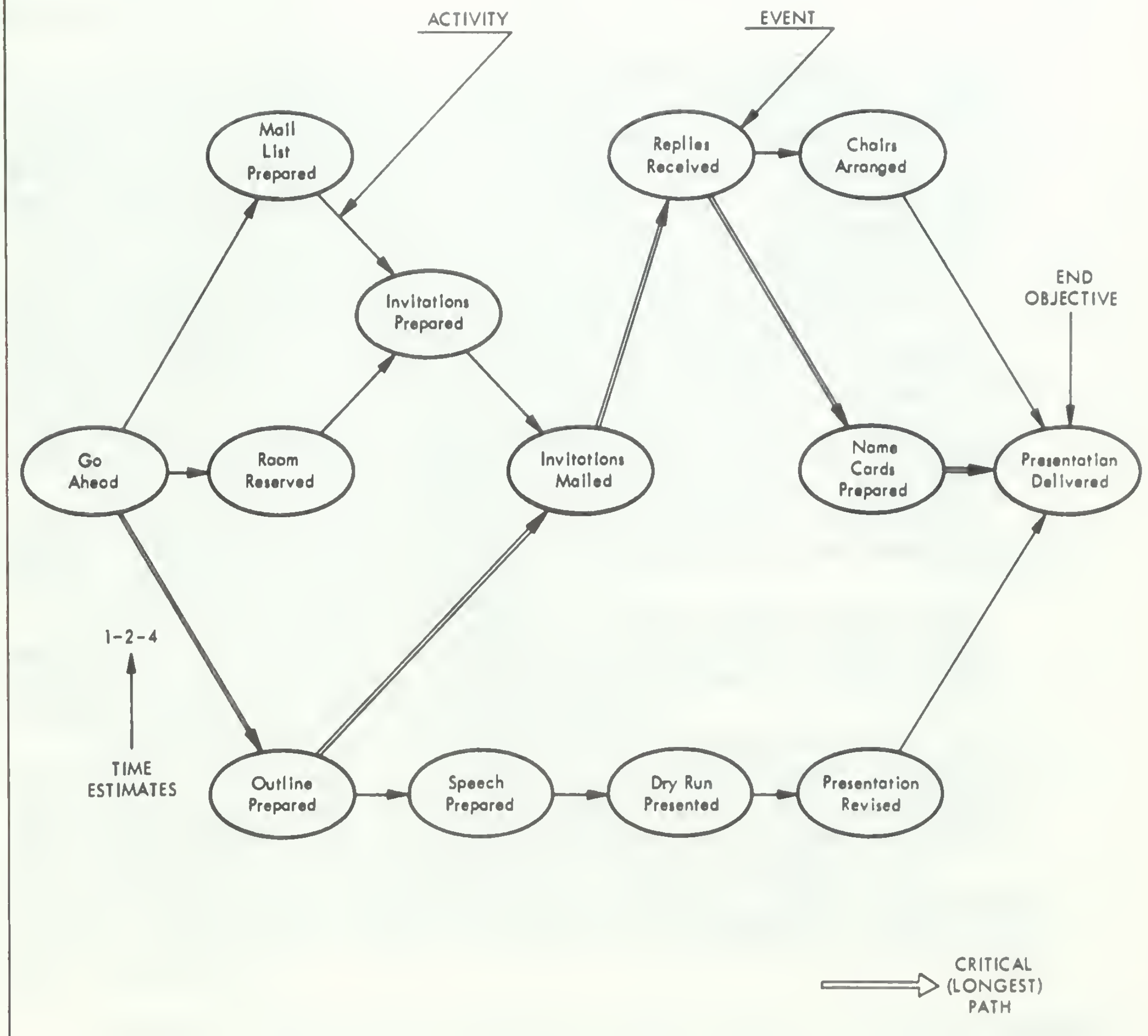

Fig. 15--PERT Network

This orientation permits the activity arrows to lead toward the right. The length of the activity arrow has no meaning.

The most significant aspect of PERT is the determination of "activity time". Most of the activity times cannot be accurately predicted due to the presence of a variety of uncertainties.

> Time estimates are made for each activity of the network on a three-way basis, i.e., optimistic, most likely, and pessimistic elapsed-time figures are estimated by the person or persons most familiar with the activity involved. The three time estimates are required as a gauge of the "measure of uncertainty" of the activity, and represent full recognition of the probabilistic nature of many of the tasks in development-oriented and nonstandard programs. . . . Interpretation of the concepts of optimistic, most likely, and pessimistic elapsed times has varied over the past few years. The definitions which, in my opinion, represent a useful consensus are as follows:
>
> Optimistic--An estimate of the minimum time an activity will take, a result which can be obtained only if unusual good luck is experienced and everything "goes right the first time."
>
> Most likely--An estimate of the normal time an activity will take, a result which would occur most often if the activity could be repeated a number of times under similar circumstances.
>
> Pessimistic--An estimate of the maximum time an activity will take, a result which can occur only if unusually bad luck is experienced. It should reflect the possibility of initial failure and fresh start, but should not be influenced by such factors as "catastrophic events"--strikes, fires, power failures, and so on--unless these hazards are inherent risks in the activity.[1]

Although the time estimates are made for each activity and placed on the network adjacent to the activity arrow, similar to the placement of course and speed on a navigational trackline, in figure 15 time estimates are made only for the

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[1] Robert W. Miller, "How to Plan and Control With PERT," Harvard Business Review (March-April 1962), p. 95.

activity between "Go Ahead" and "Outline Prepared". The activity involved here, of course, would be the preparation of the outline. As indicated, the optimistic time (a) is one day, the most likely time (m) is two days, and the pessimistic time (b) is four days. Time in this example is measured in days although any increment may be used such as hours or weeks depending upon the total time involved. No specific calendar dates are involved until after the entire network analysis is completed.

The expected time (t_e) that an activity will take is calculated from the three estimated times by means of the formula:

$$t_e = \frac{a + 4m + b}{6} \; .$$

For the example, the expected time turns out to be:

$$t_e = \frac{1 + 8 + 4}{6} = 2.17 \; .$$

The statistical relationships between these times are shown in the top of figure 16. If the activity were performed over and over again and then a graph were made of the number of times the activity consumed each particular time, the curve at the top of figure 16 would result. It can be seen that only a relatively few occurrences take place near the optimistic and pessimistic times and the greatest number occur at the most likely time, which is indicated by "m" on the abscissa directly under the peak of the curve. The expected time (t_e) for this activity is slightly greater than the most likely time (m). When the time estimates are detailed and the activities are

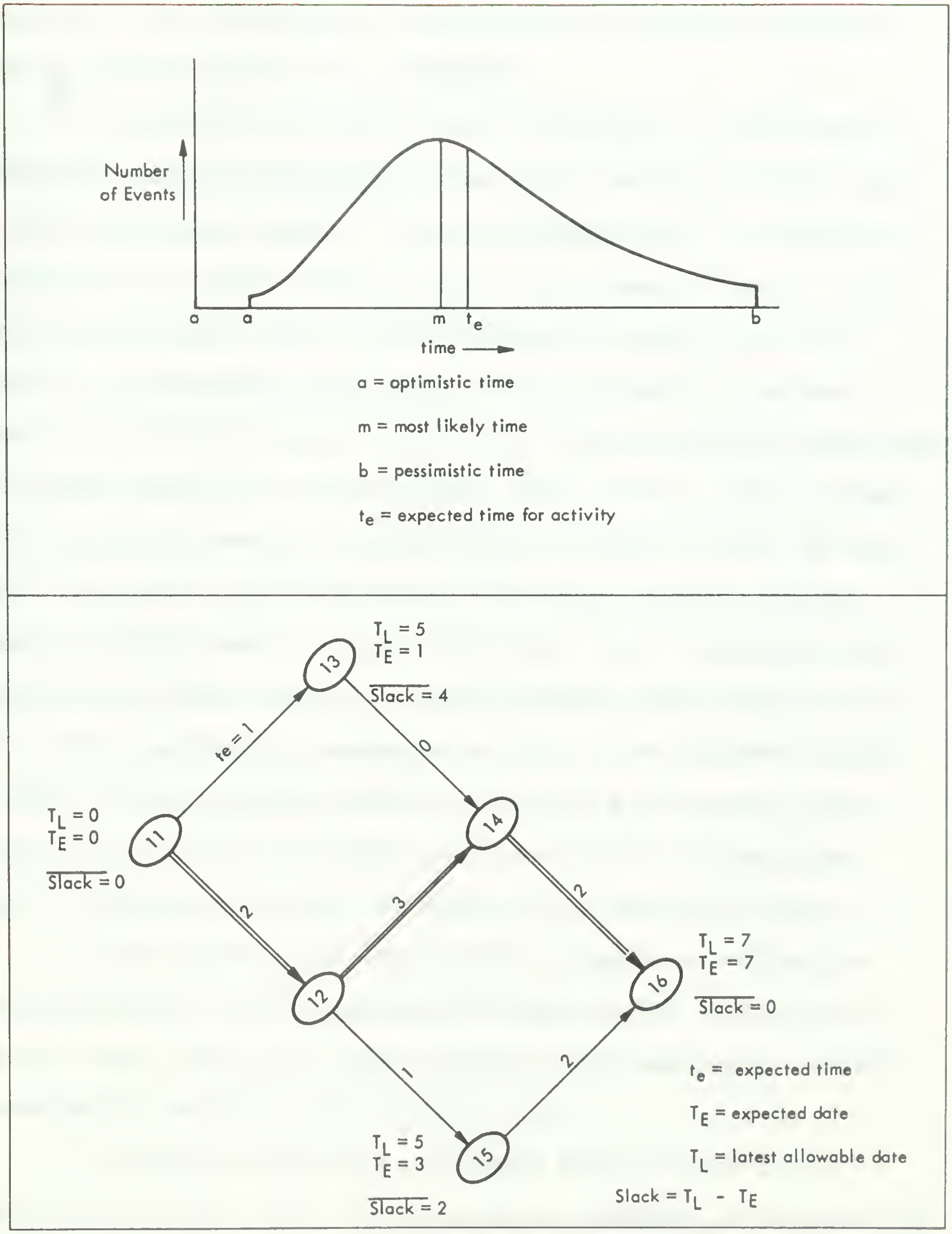

Fig. 16--Statistical Relationships (top)
and Example Network (bottom)

manifold, this statistical calculation for expected activity time is accomplished with a computer.

An expected time (T_E) for each event is calculated by adding the expected activity times (t_e) from the initial event to each subsequent event. In the network shown in the bottom of figure 16, T_E for initial event 11 is equal to zero. The expected activity time is shown adjacent to each activity arrow. T_E for event 13 is equal to one because t_e between events 11 and 13 is equal to one. T_E for event 15 is determined to be three when two (the activity time between events 11 and 12) is added to one (the activity time between events 12 and 15). It can be seen that there are several activity paths between initial event 11 and final event 16. To determine T_E for event 16, that path is selected through the network which will yield the highest summation of t_e's. The highest total of time in this network results from that path leading from event 11 to event 12 to event 14 to event 16. These times total to seven, and so T_E for event 16 is equal to seven.

This longest path through the network is called the "critical path" and is customarily shown on the network with a double line arrow or a much heavier line than those activity arrows which parallel the critical path.

The latest time (T_L) allowable for an event to be completed and still keep the program on schedule is computed by subtracting the calculated activity times (t_e) from the scheduled time (T_S) of the end objective. T_S ordinarily is

the same as T_E for the end event. T_L and T_S are then equal to seven for event 16. T_L for event 14 is equal to T_S (7) minus t_e (2) or five. T_L for event 12 is equal to two; T_L for event 11 is equal to zero. T_L for event 13 is equal to five; this is determined by starting at event 16 with a T_L of seven, subtracting two for the t_e between events 14 and 16, and then subtracting zero for the t_e between events 13 and 14. These calculations yield T_L equals five for event 13.

It can be seen that T_L coincides with T_E for all events which lie along the critical path. For those events off the critical path, there is "spare time" associated with the event accomplishment. This spare time is called "slack" and is equal to T_L minus T_E for each event. For event 15, T_L is equal to five and T_E is equal to three and so the slack is equal to two.

Looking at the slack existing within a network points out to management areas where trade-offs in resources are possible and may be desirable. All of the aforementioned times and dates including slack times can be computed periodically while the program is progressing. A study of the slack trends by management will prove most useful.

> The trend of slack, particularly on critical individual activities or events should be closely watched. Rapidly decreasing or increasing slack should alert management to changes in resources requirement and real and potential problems. Slack trend analysis makes it possible to pin point situations requiring timely management action.[1]

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[1] PERT Coordinating Group, PERT Guide For Management Use; June 1963, p. B.1.

The computer's role in PERT may be broadened by having the computer select the critical path; in complex networks where more than 200 paths exist, a computer is almost mandatory. There are also further statistical sophistications; it is possible to use the computer to calculate the variance and standard deviation related to expected times. This information can then be used to calculate the probability of meeting an established schedule-end date, T_S .

PERT has many advantages. It requires detailed plans, establishes sequential relationships, provides current status reports, points out danger areas, and aids management in scheduling, planning and evaluation.

One disadvantage of PERT which is important in connection with slack path analysis is that a network will not indicate the true time available for moving activities either forward or backward on a calendar basis.

> Calculations of critical and slack paths in PERT consider only the constraints in the program which are represented on the network. These constraints reflect the technical dependencies and interrelationships which are inherent in the work to be performed. In addition to these constraints, factors such as the availability of particular resources and facilities in specific calendar time periods are major considerations in identifying the true critical and slack paths of the program. Because of this, there is danger in thinking that the critical and slack calculations derived from a PERT network will automatically indicate the true time available for moving activities either backward or forward in calendar time periods. Before a realistic slack figure can be derived for a program, it is important to review not only the technical constraints in the program itself, but also the flexibility available in scheduling particular resources and facilities at varying time periods.[1]

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[1] Ibid., p. B.2.

There are two considerations to keep in mind in connection with the use of PERT. First of all, it is not necessary to employ a computer. Any job requiring the allocation of resources to accomplish objectives will benefit from application of PERT. In the initial example, a network was constructed to demonstrate the dependencies and interrelationships involved in planning a speech presentation. PERT could just as easily be utilized in the preparation of a meal and a myriad of other day-to-day activities. In fact, the more successful and efficient performer probably already possesses a PERT manner of thinking before ever hearing of the formal technique.

The second consideration is that PERT will not solve problems. Management must still make the decisions. PERT will point up problem areas and indicate possible "trade-offs" in resources, but it can not be a substitute for good management. PERT is a very effective management tool in the hands of a skilled administrator. With PERT the end objectives can be accomplished sooner because of the manager's efficient use of time.

PERT Cost is a natural extension of PERT to those situations in which financial resources are significant. PERT Cost adds money to time as a primary consideration in a scheduled program.

> PERT Cost utilizes the work breakdown structure and the network as the common framework for planning the schedule and cost of the program. As in the PERT system, the program is first defined and then broken down into end item subdivisions and then into the work

> packages to be assigned to first-line supervisors. These work packages are then represented by activities (one or more) on a conventional PERT network to identify the interdependencies in the program and the sequence in which the work will be performed.[1]

The computer's role in PERT Cost can be enlarged from that of PERT. The computer can maintain cost records of estimates, budgets, and actual cost. It can file and arrange cost by charge number, performing organization, resource code, and calendar period. The computer can accumulate and summarize cost according to work breakdown structure, define begin and end dates of work packages, perform cost calculations, and prepare PERT Cost output reports.

PERT Cost has proved most helpful to large contractors who are managing projects for the Defense Department. Some future date will probably see PERT Cost required of all companies doing business with the U. S. Government. In the meantime, many organizations are adopting the technique for their civilian activities as well.

> The PERT Cost System is directed toward the dynamic management of projects by the contractor, as well as toward the timely, accurate reporting of project status to the customer. The System specifies techniques and procedures to assist project managers in:
>
> - Planning schedules and costs
> - Determining time and cost status
> - Forecasting manpower skill requirements
> - Predicting schedule slippages and cost overruns
> - Developing alternate time-cost plans
> - Allocating resources among tasks

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[1] PERT Coordinating Group, PERT Guide For Management Use; June 1963, p. 39.

> PERT Cost provides an integrated framework for effective management decisions.[1]

Preceding the development of PERT and PERT Cost, a technique known as Critical Path Method (CPM) was taking hold in the construction industry. CPM also requires the summing of activity times along the various paths to determine the longest (critical) path. The summing cannot take place, however, until the activity times have been estimated.

> It is in this time estimating procedure that PERT and CPM differ most markedly. Oriented as it is to the uncertainties inherent in the research and development project, PERT uses a statistical method to approximate the time an activity will take. By a simple mathematical formula, the expected time is calculated from three estimated times; an optimistic or shortest possible time, a pessimistic or the longest time that assumes everything will go wrong, and a most likely time that is based on normal progress.
>
> Because CPM was devised to deal with more precise activities, it uses only one time estimate, normal time. This is sufficient for a construction estimator, who can figure rather accurately how long it will take to pour 100 yards of concrete foundation. Similarly, a manufacturing foreman can tell how many hours are needed to turn 100 pump shafts of a particular design.[2]

CPM, then, is essentially PERT after a "statistectomy". The application of PERT, PERT Cost, and CPM have embraced nearly every field of human endeavor and include: weapon and space systems acquisition, missile site activations, atomic energy programs, civil defense programs, training programs,

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[1] Special Projects Office, Navy Department, An Introduction To The PERT/COST System For Integrated Project Management; 1962.

[2] John Van de Water, "PERT and CPM: New Planning Tools For Purchasing Management," Purchasing Magazine, June 3, 1963, p. 72.

manuals and reports preparation, salvage operations, administrative planning, military operations, and small business ventures. PERT's origin is credited to the Navy's Special Projects Office which applied PERT to the POLARIS program where 23 separate networks and over 3000 events were involved.

An application directly involving the Coast Guard was "Operation Chlorine" shown in figure 17.

> A barge, containing four large cylinders of deadly chlorine gas, had sunk into the mud of the Mississippi River near Natchez, Mississippi. Efforts to locate and raise the cylinders had failed, so The Army Corps of Engineers was called to do the salvage job and used critical path techniques to interface the activity. Cooperating with the Corps of Engineers were the Navy, Air Force, and Coast Guard. U. S. Public Health Service was assigned the job of responsibility for public safety. Also involved were the Mississippi National Guard, the Red Cross and the State authorities of Mississippi and Louisiana. The Air Force flew in the required materials, the Navy used magnetic detection devices to locate the sunken barge (corroborated by Navy divers), and the Army Engineers began the raising and salvage. The operation was successful and one after the other of the potentially deadly cylinders were raised and taken away.[1]

Not quite so dramatic but certainly of long-range significance has been the implementation of the Critical Path Method as the system of management control for the building of the new 157-ft. Coastal buoy tender (figure 18) at the U. S. Coast Guard Yard at Curtis Bay, Maryland. Besides being the largest vessel built at the Yard since World War II, she will possess the following characteristics: twin controllable pitch

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[1] PERT Coordinating Group, PERT Guide For Management Use, June 1963, p. A.4.

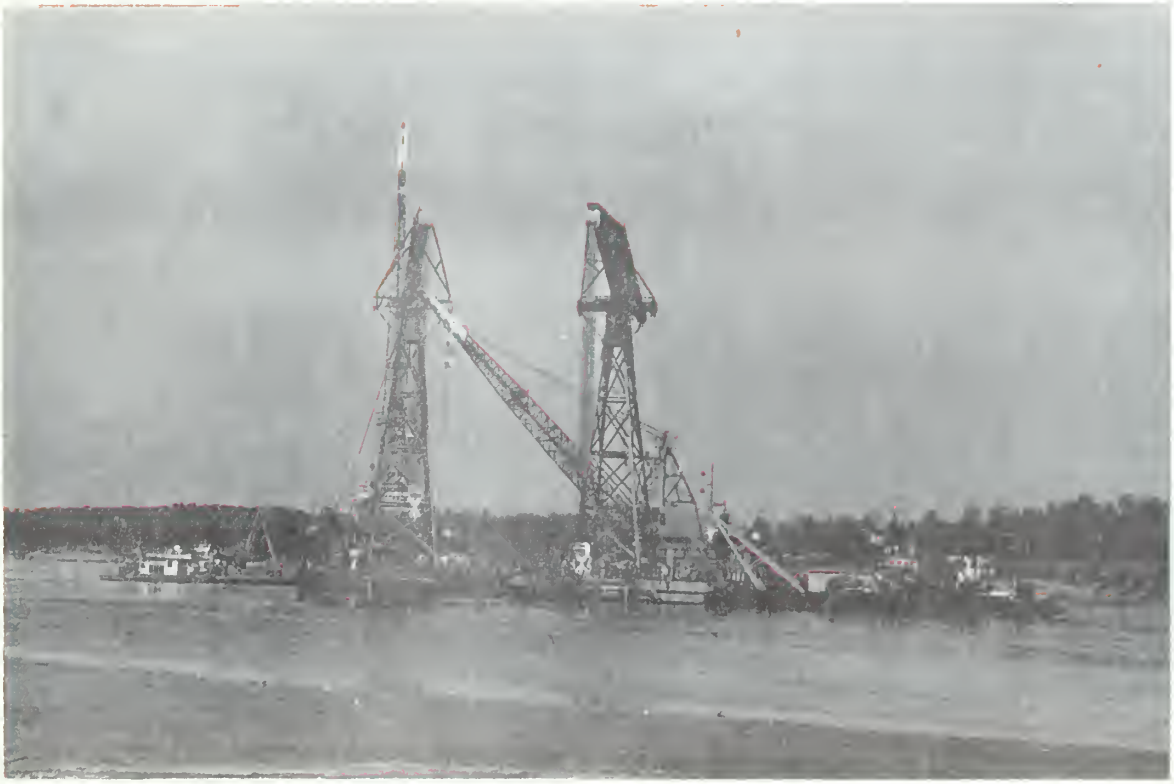

Fig. 17--"Operation Chlorine"

propellers, a bow thruster unit, steering and engine control stations on each bridge wing as well as in the pilot house, a 10-ton hydraulically powered boom controllable from either of two enclosed stations, and air-conditioned quarters for the officers and men. All of these features add to the complexity of the shipbuilding task.

Additionally, there are traditional problems to complicate the management function of the shipbuilder. Ship components procured outside the yard are usually "one-shot" orders which interrupt the supplier's established production procedures. The design of the ship and subsequent construction are subject to the influence of changes in construction

Fig. 18--157 Ft. Buoy Tender

techniques, new ideas, and errors. Traditional management procedures have provided uncertain and insufficient information to determine satisfactory progress of sub-assemblies, possible "trade-offs" in resources, and proper manning levels for the various jobs.

Clearly, a management technique is needed to assist in alleviating these special and traditional problems. The Critical Path Method has been adapted for this purpose. A small segment of the basic network employed is shown in figure 19. With this tool many of the problems have been simplified or overcome. Procurement and supply functions have been carried out more efficiently with firm and controlled dates assigned to system components. CPM pointed out to the Design Branch

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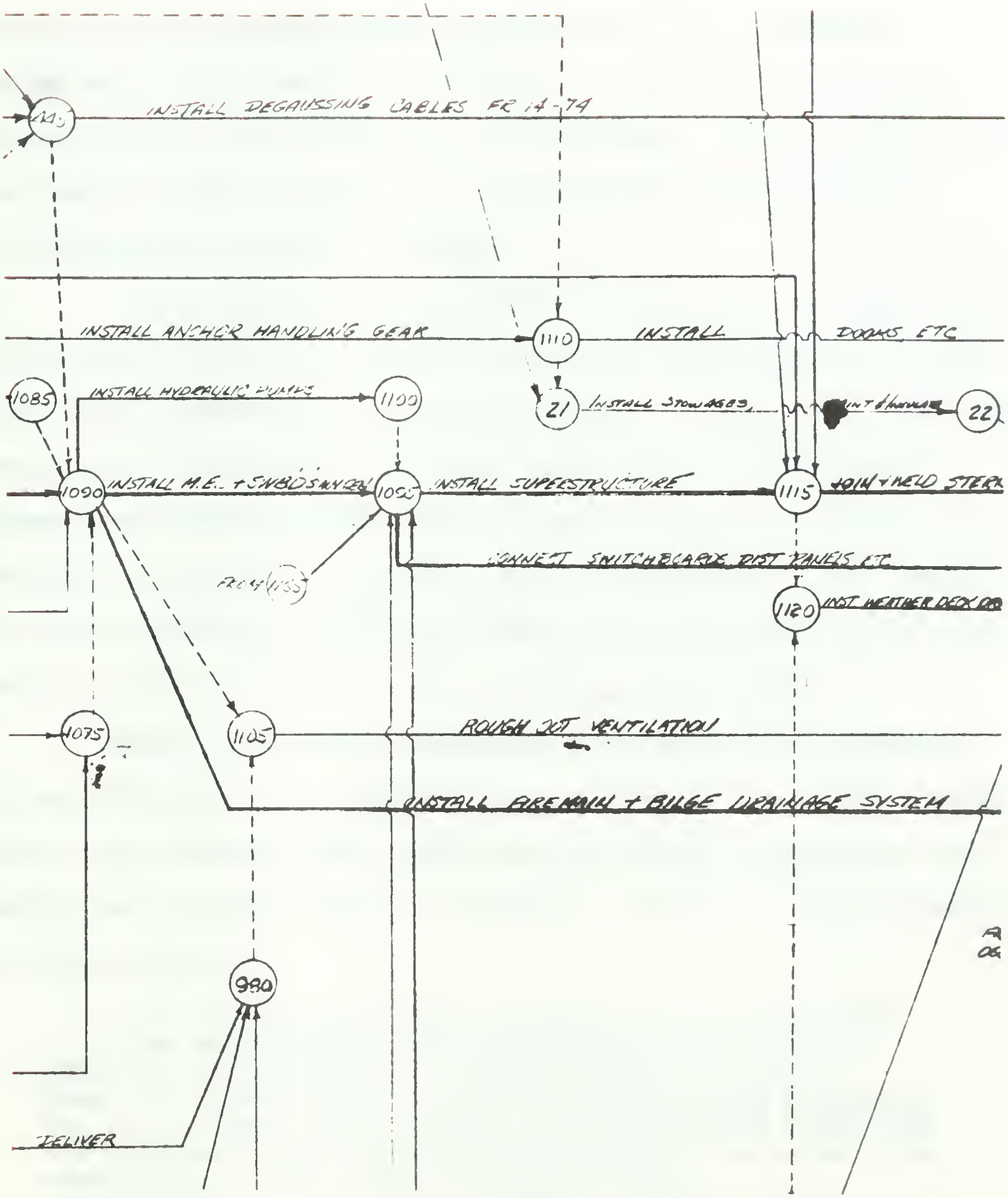

Fig. 19--Segment of CPM Network

that the bow thruster specification had to be expedited. Additional sub-assemblies involving air port cuts and frame installations were indicated to Production. Most important was the result that time and cost requirements were predicted more accurately than ever before.

Following the establishment of the network, the slack was distributed to the various activities resulting in a start date and a finish date for each activity. These dates have been designated PALF (Prior Activity, Latest Finish) and MFTAB (Must Finish This Activity By). Next, a project schedule was derived; a portion of this is shown in figure 20. Job orders for every activity were then written and were distributed with copies of the network to shops, Design, and Supply.

Coast Guard Yard management personnel have determined to mesh CPM with the computer "on a slow bell." At the present time, only material cost sheets and the weekly cumulative cost report are obtained from the computer. However, future benefits are being planned.

> In a repeating project, where more than one ship is to be constructed, the activities of a revised network, which includes the cost accounting data from the first ship, will become actual work standards for the project, with proper modification to allow for the productivity increase which naturally results from repetition. This revised network would . . . be susceptible to the myriad computer programs available for application.
>
> At this point, it is possible to visualize a future application in all new construction within a shipyard where computer techniques would make it possible to "stagger" projects in such a way as to minimize work load fluctuations on a yard-wide basis.[1]

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[1] Lieutenant Commander David M. Kaetzel, "A System of Management Control Applied to Shipbuilding," The Journal of the Society of Naval Engineers, February 1963.

157' COASTAL TENDER PROJECT SCHEDULE(DATED) FROM CPM
CHRONOLOGICAL SEQUENCE

ACTIVITY	DESCRIPTION	Prior Act. Latest Fin.	Must Fin. this Actvy
0-560	Vent Fans	11-19-62	12-10-62
0-560	Prepare BM #115 Vent Fans	11-19-62	12-10-62
0-640	Bow Thruster	11-19-62	12-17-62
0-640	Prepare BM #113 Bow Thruster	11-19-62	12-17-62
0-735	Aux. Gen. Grid Cooler	11-19-62	12-17-62
0-735	Prepare BM #114 Aux. Gen. Grid Coolers	11-19-62	12-17-62
0-570	Specs. for Stern Tube Seals	11-19-62	12-31-62
0-570	Prepare BM #119 Stern Tube Seals	11-19-62	12-31-62
0-575	Specs. for Cutless Bearings	11-19-62	12-31-62
0-575	Prepare BM #118 Cutless Bearings	11-19-62	12-31-62
0-580	Specs. for Cont. Pitch Propeller & Shafting	11-19-62	1-7-63
0-5	Group I Hull Structure 1101-1 1103-2 1105-2 1103-1 1105-1 1106-1	11-19-62	1-7-63
0-700	Main Eng. Aux. Gen. & Red. Gear Spec.	11-19-62	1-7-63
0-555	Write Specs. for Airports	11-19-62	1-14-63
0-555	Prepare BM #101 Airports	11-19-62	1-14-63
0-12	Prepare Specs & BM for Degaussing Remote Control Panel	11-19-62	1-21-63
640-645	Bids & Contracts & Cert. Plans Bow Thruster	12-17-62	1-28-63

Fig. 20--Project Schedule

The initial success of the adaption of CPM has resulted in its use in the construction of additional 157-ft. tenders, 44-ft. boats, and 210-ft. ships at the Coast Guard Yard.

The ship construction and "Operation Chlorine" are two "in-house" examples of CPM application. The future will probably bring many uses for PERT and PERT Cost as well.

CHAPTER V

LOGISTICS MANAGEMENT

Logistics Management refers to the planning, coordination, and control, of the consumption, storage, and movement of all items which are necessary to support a command in the discharge of its mission. Every man and every piece of equipment must be supplied with energy in some form---food or fuel; also required are spare parts, medicine, and other consumables, such as raw stock, rags, missiles, shells, lubricants, paper, lightbulbs and so forth. In figure 21 can be seen the USCGC Eastwind in McMurdo Sound, Antarctica, offloading supplies to support the United States scientific mission in the frozen continent. It is apparent from the sheer magnitude of the support function that much is to be gained from a well-oriented, well-coordinated operation. The appearance of computers on the scene has made possible a coordination which could not be achieved in the past.

Every ship has an allowance list which delineates the material authorized to be installed or carried aboard the ship for use by the unit. In the past, development of this allowance list of recommended quantities of equipage, spare parts and consumables has been done in piecemeal fashion with each weapons system and each engine having its own allowance list; these were added together to form the ship's list. As the

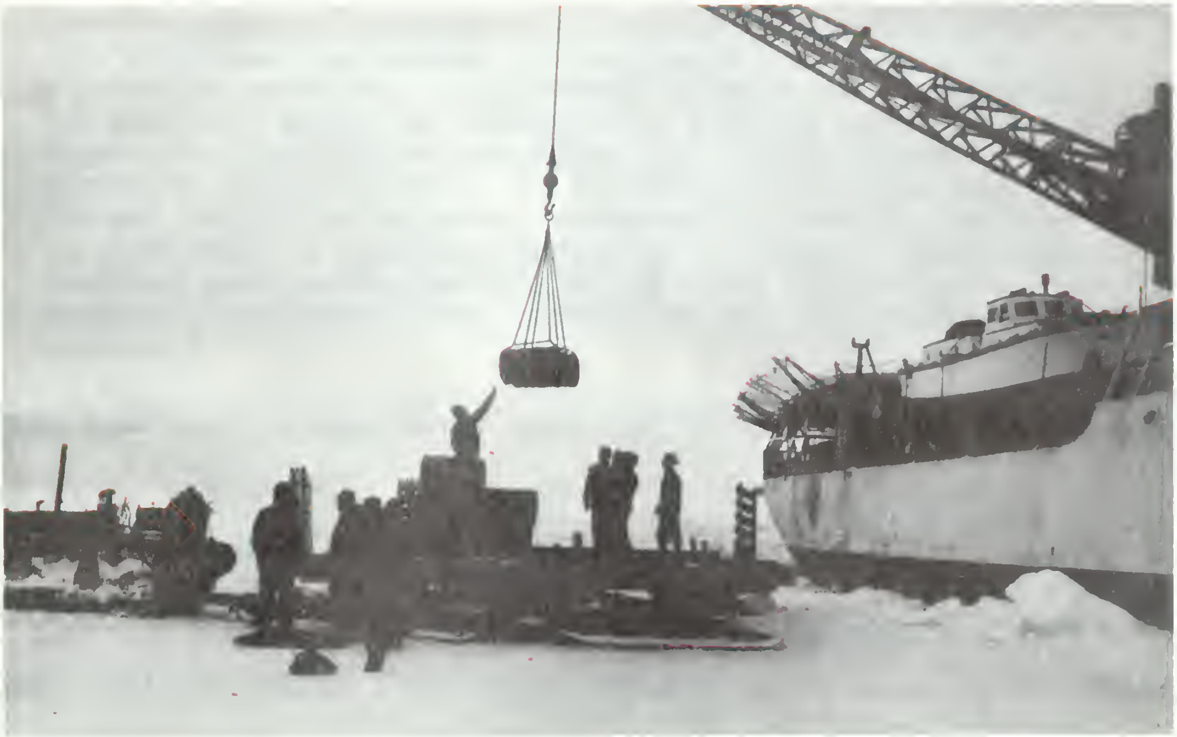

Fig. 21--USCGC Eastwind in McMurdo Sound, Antarctica

number and complexity of systems has increased, the required support in repair parts and consumables has increased markedly. The widespread use of Electrical Accounting Machines and Electronic Data Processing Machines has provided solutions to many of the previous problems involved in allowance list preparation. Now, engineers, technicians, and statisticians look at the operational history of similar ships, at the equipment with its components and parts and study the recommendations of manufacturers. With a computer they can determine the probability and incident rate of failure. One of the results of this type of study has been a Coordinated Shipboard Allowance List (COSAL).

> The Coordinated Shipboard Allowance List establishes the shipboard allowance for installed and portable equipment, equipage and directly supporting material. It does not apply to consumables such as medical supplies, provisions, clothing and small stores, or aircraft repair parts. It is designed to give the vessel an allowance list, standard in format, capable of achieving a balanced duration of support among the various equipments to enable the ship to have a maximum, selfsupporting capability for an extended period.[1]

COSAL has been successfully utilized by the Navy in four areas: (1) hull, mechanical, and electrical, (2) electronics, (3) ordnance, and (4) aviation catapult and arresting gear. Basically, to determine a COSAL requires looking at perhaps three devices aboard ship which require tubes type 6SHJ. Then, instead of keeping one spare for each device, the ship will maintain only one or two tubes in a spare parts status after consideration of the failure rate for all. The Coast Guard has adopted COSAL for electronics allowance lists only.

Also aboard ship, the Navy has recognized the need for a command and control system in logistics and has installed Electrical Accounting Machine (EAM) systems in 27 ships. These include the fleet issue ships, the AKSs, the AFs, the submarine tenders, the destroyer tenders, repair ships, and one aircraft carrier. The Navy anticipates[2] that it probably will not be possible to install EDP equipment in Destroyers and smaller ships; they do expect to install key punch equipment and have

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[1] Supply Management Technical Publications (Athens, Georgia: United States Naval Supply Corps School, 1960), p. 10-1.

[2] Captain R. R. Campbell, "Logistics Management in the Fleet," U. S. Naval Institute Proceedings (October 1963), p. 88.

a data processing installation in a nearby command organization, which, in the case of destroyers, would be in the destroyer tender. The Coast Guard has no EAM equipment or computers for supply purposes on any ship.

The Navy is also investigating the use of the computer in the Navy Tactical Data System for use in supply functions. Experiments are being conducted on three vessels in the Pacific and two in the Atlantic.

> The NTDS computer alone is not sufficient to operate a logistics data system. With adequate programs and peripheral equipment in the ship, however, the computer can be used during tactical off-time to update the various logistic programs handled 'off-line' elsewhere. These installations show what a digital computer can do afloat in logistics; we cannot rely on them for the future, however, because of their primary commitment to tactics.[1]

Supplies are provided to the ships within the Department of Defense by the Defense Supply Agency (DSA). DSA has used EDP equipment in a variety of applications in the Defense Supply Centers: requisition processing, stock record maintenance, maintenance of material request and status history files, catalog records maintenance, materiel management, and billing and collecting. Defense Supply Depots are storage locations which perform a shipping and warehousing function for the Defense Supply Centers. The depots make use of computers in shipment processing, receipt processing, and adjustment processing. The use of computers has led to an integration and centralization of supply which has not been possible in the past. Stock levels

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[1] Ibid.

can be maintained on a systemwide basis and shipments to customers can come promptly from a location which has the required material on hand and is located so that the most economical transportation is involved. One of the advantages of this system will be an overall reduction in the costs not only of administration but also of inventory maintenance.

At Norfolk, Virginia, there is an IBM 1410 system at the Naval Supply Center which processes requisitions at the rate of 14,000 to 30,000 a day. When an order is received, the computer will check to see if the item is in stock, direct the clerk to the location of the item, and update the inventory and financial records simultaneously. If the item is to be shipped, a shipping invoice and shipping label will be printed by a terminal of the device located at the proper warehouse. The 1410 also will record incoming material, checking to see that it was ordered and instructing the receiving department exactly where to store it. It will then update the stock records. In its spare time the 1410 system also handles all of the center's fiscal information, including payroll, savings bonds, and leave accounting. In Philadelphia the Navy Aviation Supply Office has been automated. The ASO is the inventory control point for all aeronautical material used by the Navy and Marine Corps. The significant advance made by ASO has been in procurement processing of purchase orders for stock replenishment. The output of the operation is an EAM card which is itself a request for quotation (RFQ)--one card for each item and each destination. RFQ cards are sent to all manufacturers who are

identified in the activity's technical files as being suppliers of the item to be purchased. The supplier writes in his price, delivery date, and discount terms, and returns the cards to the ASO, where they are reviewed by procurement agents. Those accepted are sent back to the computer which produces a purchase order.

The Marine Corps also is employing computers in supply functions. Computers have been installed in the Marine Corps supply centers at Albany, Georgia, at Barstow, California, and at the inventory control point in Philadelphia. The functions of the computers are the economical and accurate inventory control of approximately 250,000 supply items along with financial control and managerial reporting.

The United States Army recognizes the modern challenges of logistics management.

> Until recently there were no scores of supply centers nor vast worldwide communication and transportation networks; nor did a single event or engagement usually have such far-reaching effects as it might today when "logistics" embodies a whole intricate art in itself, encompassing the efforts of thousands of specially-trained people and billions of dollars worth of equipment and supplies.[1]

Charged with the responsibility of training Army personnel in modern logistics management is the U. S. Army Logistics Management Center (ALMC) at Fort Lee, Virginia. Employing an IBM RAMAC 305 in part of its program, ALMC conducts an inventory management "game" called LOGSIM-WC (Logistics Simulation-

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[1] United States Army Logistics Simulation with the IBM RAMAC 305 (Rockville, Maryland: IBM Federal Systems Division), p. 1.

Wholesale, Computer Assisted). Mathematical models of complex problems drawing on all of the elements of the U. S. Army wholesale supply system stored in the RAMAC 305 give the students all the benefits of real world experience without the actual consequences of errors.

A significant step in the automation of logistics management was made with the implementation of MILSTRIP on 1 July, 1962.

> The Military Standard Requisitioning and Issue Procedure (MILSTRIP) concept was created in order to establish and implement uniform criteria for preparation and submission of single line item requisitions by the Military Services.
>
> The procedures, forms, and formats . . . are mandatory for all Coast Guard units in intra-service, inter-service, and CG-GSA transactions. In addition, the general MILSTRIP system concept is binding on all members of the Department of Defense and on the General Services Administration in its logistics support of the Military Services.[1]

MILSTRIP applies to all manner of supplies, such as the dry stores shown in figure 22 at the Coast Guard Receiving Center at Cape May, New Jersey. Important also are those circumstances in which MILSTRIP does not apply. These include: perishable and brand name subsistence items, bulk fuels and lubricants, purchasing operations within or between departments, some forms and publications, material controlled by the U. S. Navy Oceanographic Office, optional use for transactions within stations or bases for local support, Stock Number Identification Tables (SNITS) and Allowance Parts Lists (APL's) for electronic parts.

Fig. 22--Dry Stores at Cape May, New Jersey

Three forms have been created for use in MILSTRIP documentation. Two are EAM cards compatible for EDP. DD Form 1348 is used for requisitioning, follow-up, cancellation, status request, shipping data request, and for receiving material requisitioned from Coast Guard Supply Activities. DD Form 1348m is a standard EAM card which is used in DOD and GSA systems for requisitioning, follow-up, cancellation, status detail, and various orders. Coast Guard activities receive 1348m from DOD or GSA in reply to follow-up, status request, shipping data request, and cancellation request. DD Form 1348m

is also authorized for interservice use by Coast Guard units having ADP capability. The third form associated with MILSTRIP is DD Form 1348-1 and is shown in figure 23.

> Material from components of DOD and GSA supply systems will normally be received on this form. The Coast Guard will use the DD-1348-1 for release of all material consigned to all activities other than the Coast Guard. This form will also be used intra-Coast Guard for the turn-in of all material to the supply system, for requests for disposal and for all HQCM issues. When components of DOD and GSA use the DD-1348m (mechanical) system, the DD-1348-1 will be used as the material release document.[1]

Another step forward in logistics management was taken when MILSTAMP became effective on 1 October, 1963.

> The Military Standard Transportation and Movement Procedures (MILSTAMP) are a set of standard procedures, forms, and language to be used by the military services and all other agencies which use the DOD transportation system.[2]
>
> With the evolution of a military supply and transportation system which encompasses all the services, there has arisen a need for a standard documentation system which is readily usable and understood by the various services and agencies involved. Just as the Military Standard Requisition and Issue Procedures (MILSTRIP) were conceived by DOD to streamline certain basic supply procedures throughout the service, MILSTAMP has been promulgated to provide a common system for documenting and controlling movements within the DOD transportation system.[3]

The purposes of MILSTAMP are to make the DOD transportation system more effective to the user and to increase

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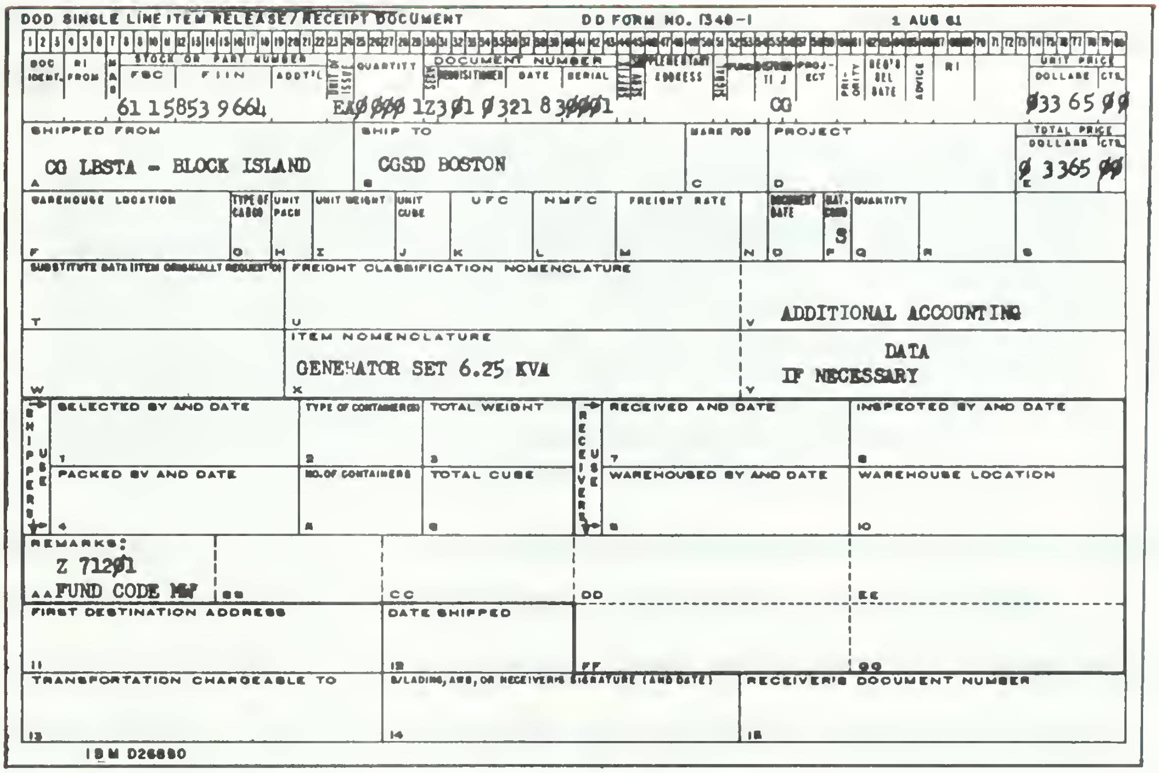
[1] United States Coast Guard MILSTRIP Operating Manual (Washington, D. C.: 1962), p. Ch. 4 1-3.

[2] Navy MILSTAMP Training Guide (Washington, D. C.: July 1963), p. 1-1.

[3] Ibid.



DOD SINGLE LINE ITEM RELEASE/RECEIPT DOCUMENT
DD FORM NO. 1348-1
1 AUG 61

DOC IDENT. | RI FROM | M & S | STOCK OR PART NUMBER: FSC, FIIN, ADDT'L | UNIT OF ISSUE | QUANTITY | DOCUMENT NUMBER: SERV, REQUISITIONER, DATE, SERIAL | DEMAND | SUPPLEMENTARY ADDRESS | SIGNAL | FUND | DISTRIBUTION | PROJECT | PRIORITY | REQ'D DEL DATE | ADVICE | RI | UNIT PRICE: DOLLARS, CTS.

61 15853 9664 EA0000 12301 0321 830001 CG 033 65 00

SHIPPED FROM: CG LBSTA - BLOCK ISLAND (A)
SHIP TO: CGSD BOSTON (B)
MARK FOR (C)
PROJECT (D)
TOTAL PRICE: DOLLARS, CTS.: 0 3365 00 (E)

WAREHOUSE LOCATION (F) | TYPE OF CARGO (G) | UNIT PACK (H) | UNIT WEIGHT (I) | UNIT CUBE (J) | UFC (K) | NMFC (L) | FREIGHT RATE (M) | (N) | DOCUMENT DATE (O) | NAT. COND (P): S | QUANTITY (Q) | (R) | (S)

SUBSTITUTE DATA (ITEM ORIGINALLY REQUESTED) (T)
FREIGHT CLASSIFICATION NOMENCLATURE (U)
(V) ADDITIONAL ACCOUNTING DATA IF NECESSARY (Y)
(W)
ITEM NOMENCLATURE: GENERATOR SET 6.25 KVA (X)

SHIPPERS USE: SELECTED BY AND DATE (1) | TYPE OF CONTAINER(S) (2) | TOTAL WEIGHT (3) | PACKED BY AND DATE (4) | NO. OF CONTAINERS (5) | TOTAL CUBE (6)
RECEIVERS USE: RECEIVED AND DATE (7) | INSPECTED BY AND DATE (8) | WAREHOUSED BY AND DATE (9) | WAREHOUSE LOCATION (10)

REMARKS:
Z 71201
FUND CODE MW (AA)
(BB) (CC) (DD) (EE)

FIRST DESTINATION ADDRESS (11)
DATE SHIPPED (12)
(FF) (GG)
TRANSPORTATION CHARGEABLE TO (13)
B/LADING, AWB, OR RECEIVER'S SIGNATURE (AND DATE) (14)
RECEIVER'S DOCUMENT NUMBER (15)

IBM D26880

Fig. 23--DD Form No. 1348-1

the intrinsic efficiency of the system. Toward these ends, MILSTAMP incorporates the following: shipment planning, uniform documentation with the Transportation Control and Movement Document (TCMD) DD Form 1384, compatibility with MILSTRIP, standard transportation priority based on Uniform Material Issue Priority System (UMIPS), performance evaluation by in-transit data collection, and a Transportation Account Code (TAC).

Mandatory for all military services and other agencies using the DOD transportation system, MILSTAMP does not apply to local shipments, mail shipments, commercial bills of lading shipments, bulk petroleum products shipments, and passenger movements.

More automation progress will be accomplished with the

proposed implementation on 1 October 1964 of the MILSTAAD Joint Regulation.

> This regulation implements the policy of the Department of Defense respecting development, implementation and maintenance of a Military Standard Activity Address Directory (MILSTAAD) for use in military standard logistics systems. The broadened application of automatic data processing, the use of high speed data transmission equipment, the shortening of logistics pipelines, and the continued increase in supply cross servicing make it highly important that activity codes and clear text addresses be uniform in content and structure to facilitate usage in automated systems.[1]

The system provides for a 6-digit alpha-numeric code for fixed installations, mobile activities, and certain contractors. The address code is an important part of MILSTRIP, MILSTAMP, and MILSTRAP. MILSTRAP stands for Military Standard Transaction, Reporting, and Accounting Procedures which are internal to DOD and hence do not apply to the Coast Guard.

The advent of automation in logistics management has been accompanied by such an explosion of acronyms that one waggish Navy Admiral remarked, "Now that MILSTRIP, MILSTAMP, MILSTRAP, and MILSTAAD are at hand, we will probably soon have a MILSTONE around our necks---MILitary STandardization Of Nearly Everything."[2]

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[1] MILSTAAD, MIlitary STandard Activity Address Directory Joint Regulation (Washington, D. C.: DRAFT March 1964), p. 1.

[2] Name withheld by request.

CHAPTER VI

INFORMATION RETRIEVAL

Information Retrieval is a relatively new field of endeavor, but the problem with which it deals is not new; essentially it is the problem of organizing and filing information so that it is readily available when needed. Early efforts were principally in scientific and technical applications, but there has been an increasing awareness of its potential for general business and management uses. In the Coast Guard, the Office of Personnel is expanding its modern information retrieval methods. The office of Merchant Marine Safety will soon adopt a system for its many blueprints. Other potential uses would be for legal and intelligence files or for any other large accumulations of printed matter that must be referred to periodically. It may be that the Academy library will follow the planned automation of the Library of Congress.

Recognition of the need for more efficient systems for managing the valuable resource, information, is not something of recent origin. As early as 1851, in a report to Congress, the Secretary of the Smithsonian Institution said:

> It is estimated that about twenty thousand volumes, including pamphlets, purporting to be additions to the sum of human knowledge, are published annually; and unless this mass is properly arranged, and the means furnished by which its contents may be ascertained,

> literature and science will be overwhelmed by their own unwieldy bulk.[1]

But this warning and others like it went unheeded for over a century and literature of all types kept piling up, being indexed and filed by the conventional manual library methods. The real information explosion came during and after World War II when there was a tremendous expansion in scientific and technological research. The flood of knowledge was so great that the traditional methods of collecting, classifying, and storing records could no longer handle the problem effectively.

Here are some actual incidents[2] that illustrate how research expenditures by private industry and the government were spent unnecessarily for duplicated effort because of lack of easy access to already existing knowledge:

> In development of a military communications system, government scientists struggled with an electronic switching problem for several years before finally solving it. They later discovered that the Russians had published the solution to the same problem in 1950, about the same time that we began working on it.
>
> In another case, missile firings were delayed for 4 months while several U. S. manufacturers worked on a tricky valve design. The Air Force then discovered that it had the answer all along, buried in its files.
>
> One electronics firm paid 8 million dollars developing 2 devices only to discover it had wasted its money. Earlier inventors already had patents on similar devices which were buried in the files of the Patent Office.

The information problem is not limited to science and engineer-

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[1] Allen Kent, Textbook on Mechanized Information Retrieval (New York: John Wiley & Sons, 1962).

[2] Francis Bello, "How to Cope with Information," Fortune, September 1960, p. 162.

ing only. Every year the federal government turns out 25 billion pieces of paper in the form of reports, letters, publications and other documents. Laid end-to-end, this paper would stretch to the moon and back 13 times. The accumulation of documents in the federal records centers consumes space equivalent to 7 Pentagon buildings.[1] The government and private industry have a tremendous paper tiger by the tail; management has become acutely aware that the success of any organization depends to a great degree on the availability of timely, accurate, and complete information for decision-making.

The efforts to cope with this information problem have led to the new and rapidly developing field of Information Retrieval systems, which are defined as: "Systems for locating and selecting, on demand, certain documents, or other graphic records relevant to a given information requirement from a file of such material."[2] The fundamental purpose of these systems is to organize and file information in such a way that it can be made available when it is needed. In principle there is nothing strictly new about Information Retrieval. The familiar library systems, such as the Dewey decimal system for indexing, filing, and retrieving literature, have been in use for a long time. But these manual systems have proven inadequate to cope with the vast amount of information now being

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[1] Victor H. Nash, "A Decision in the Making: Automatic Files for Government and Business," The Armed Forces Comptroller, June 1962, p. 14.

[2] U. S., Bureau of the Budget, Automatic Data Processing Glossary, December 1962, p. 54.

generated. As a result, more versatile devices and equipment, and more sophisticated methods and systems are being developed to solve the problems.

The operation of an Information Retrieval system is comprised of the following basic functions:

a. Collection. This function involves the acquisition of the source documents that will enter the system. The major problem here is to insure access to all of the information needed to fulfill the requirements of the system.

b. Analysis. Next, the input must be analyzed and evaluated to determine if it is of value and if it supersedes or adds to information already in storage. Extraneous data must be screened out to avoid clogging the system with useless information.

c. Abstracting. Some, though not all, systems utilize abstracts. Abstracing involves the condensing of a publication, article, or some other type of document into a concise summary of its essential contents. Abstracts obviate the necessity of referring to the original document. In some applications they serve to keep users of the information system informed of current developments and new information entering the system. They are also useful as a basis for indexing. Automatic abstracting systems have recently been developed in which a computer makes a statistical analysis of the most frequent significant "key words" in a document and automatically produces an abstract composed of the sentences which contain the

highest density of key words.

d. Indexing. A fundamental requirement of any Information Retrieval system is effective indexing. The index is the key to control over the information in storage. Alphabetical and numerical identifiers or the standard library classification systems may be adequate when the number of subjects is not too large. However, these classification systems are rigid; documents must be fit into pre-established fixed categories, and retrieval may prove difficult if the user's approach does not match the approach used in classifying the document. New, more flexible indexing systems such as the key word, the descriptor, and other systems are now being used extensively. Once the index has been developed, it can be coded for machine processing and serve as the basis for searching and retrieving of data from storage.

e. Storage. This function is concerned with the physical storage of the original record, the abstract, and the index. In some systems, the index and abstract are stored on a machine searchable medium and the original documents are stored separately in their original form. This approach is suitable when dealing with documents which are extremely bulky or otherwise do not lend themselves to transfer to other media. In other systems, the documents are stored along with the index and abstract in machine searchable form. The physical form of the documents and the manner in which they are used have a major influence on the type of storage suitable. There are various storage media including microfilm, edge-notched

cards, "peek-a-boo" cards, aperture cards, punched cards, magnetic tape, and random access magnetic discs.

f. Retrieval. The culmination of the information system is retrieval of the stored data. Although listed last, the retrieval function is of first importance because the requirements of retrieval will largely determine how the other functions will be performed, what will be collected, whether or not abstracts will be used, the type of index, and the type of storage equipment to be employed. Whatever the requirements, the prime consideration and the end result of the system must be to satisfy the needs of those who use the information.

In approaching the information problem, the first and foremost matter for management to identify is: What is needed? Not what kind of equipment is needed but rather what are the information needs? Equipment is available to meet just about any requirement, but no system exists as a package ready to be plugged in and be suitable for any and all requirements. There are a number of factors for management to consider in selecting a system for a particular requirement. The major considerations are:

a. Purpose of the system. As in all planning problems, the first step is to define the objective. Why is the information collected? How is it used? Only after these questions have been answered can it be determined what to collect, how much to collect, and how to process it.

b. System users. The system should be user-oriented. Effectiveness implies that the product produced by the system

be useful to the people who will use it. Basically, the system must provide: (1) enough information, (2) of the kind that's needed, (3) when it's needed, and (4) in the form needed. The user's requirements are a major determinant not only in the form of output but also in the speed of response. For example, an information system for a military command application would demand rapid results, whereas the time element in a scientific research application would be of lesser significance.

c. Nature of information handled. The form, type, and volume of the source documents have a major bearing on the type of system to be adopted. The nature of the input is an important consideration in determining whether the system should produce a bibliographic reference, an abstract, or a reproduction of the document, what type of storage media should be used, and how much storage capacity is needed.

d. Cost of the system. The capital investment and operating costs are major considerations in design of the system. Management must avoid the temptation of becoming enamored of the machines and devices. The information system, like any other investment, should pay its own way and more. The costs must be weighed against the savings in time and duplication of effort, improved operating results, better decision-making ability, and other benefits of the system.

e. Potential for expansion. The system should have a built-in potential for growth to handle increases in the volume of data handled. Also to be considered is the possibility of adding new subject areas to the system.

f. Technological advances. Since Information Retrieval is a rapidly developing art, technological advances are another factor to consider, to avoid investing in equipment that may become prematurely obsolete. Unless the long-run requirements of the system can be projected, equipment rental may be wiser than outright purchase in the initial stages of a large-scale installation.

Indexing is the key function in the establishment of an Information Retrieval system. Use is still made of the traditional methods of organizing information. Documents are still classified on the basis of their subject contents and arranged according to a predetermined classification plan. An example of this type of stowage is the office subject correspondence files. In addition to this hierarchical classification system, there is also a separate indexing system by subject headings used widely in libraries. An example of both--a combined hierarchical with separate index records--is the Dewey decimal system. Many problems arise in the use of these traditional systems. For the hierarchical system, subject topics may be too numerous. The system is too inflexible when the documents must be retained for extended periods of time. The continual growth of the system requires subclassification or increased "depth" in classifier indexing. In the use of subject heading cards there are also problems to be overcome. The cards are widely separated in the file and hence are hard to compare. There is difficulty in revising, updating, and purging the cards. As a result of these problems with old

types of information organization and the recent increase in the amount of information, there has come about a new approach to the storage and retrieval of information.

This new approach is called "coordinate indexing". There are other names for this idea and there are several variations. Some of these are called "concept coordination", "correlative indexing", and "multiple aspect indexing". With this new concept of coordinate indexing, the major difference from traditional indexing methods is that the documents involved are not characterized by the general subject topics. Instead numerous individual words or terms are used to describe the documents---each term covering a single aspect of the document. The great advantage of this new system are its flexibility and its susceptibility to manipulation. For example, if information is put away or stored by the coordinate index system and a search is made for a particular document, the scope of the search can be broadened by dropping some of the initial terms or the search can be made more specific by adding more terms. The search can also be varied by using different combinations of terms.

There are two basic methods for selecting the indexing terms to be employed in a system:

a. Derived Index. This method uses terms appearing in the document itself. The index terms are sometimes called "keywords" and are called "uniterms" in one patented Information Retrieval system. This type of system has some problems.

There is redundancy caused by synonyms and overlapping terms. As the number of terms in the system increases, the indexing of documents becomes complicated and the searching less accurate. However, this system also has the advantage of ease and speed of indexing because all of the terms are in the "natural language" of the document. The document has not been forced to fit preselected terms.

b. Assigned Index. It may be decided in advance what terms will be used and their meaning and use defined. These assigned index terms are sometimes referred to as "descriptors". This type of selection also has its problems. It eliminates the automatic indexing of the documents; it creates an "artificial language". It thus requires special skills in devising a list of terms and places greater demands on the skill and knowledge of the indexer. However, it also has advantages. It reduces the number of terms in the system and it tends to improve the retrieval accuracy.

After the method of assigning terms to items has been determined, the next step is to assign terms; an illustration will demonstrate. A matrix relating particular document numbers to particular keywords or terms is shown at the top of figure 24. A crossmark below the document number indicates the item possesses the term over to the left of the matrix. Documents considered are numbered 1, 2, 3, 4, 5, 6, and 7. The terms that may be characteristic of a particular item are a, b, c, d, e, f, and g. Now that terms have been assigned, the information must be grouped for storage. There are two ways of doing

		Documents						
		1	2	3	4	5	6	7
Terms	a	x			x			x
	b		x	x	x			x
	c	x	x			x	x	
	d		x	x	x		x	
	e	x	x		x	x		
	f			x		x		x
	g	x		x		x	x	x

1	2	3	4	5	6	7
a c e g	b c d e	b d f g	a b d e	c e f g	c d g	a b f g

Conventional Grouping (term on item)

a	b	c	d	e	f	g
1 4 7	2 3 4 7	1 2 5 6	2 3 4 6	1 2 4 5	3 5 7	1 3 5 6 7

Inverted Grouping (item on term)

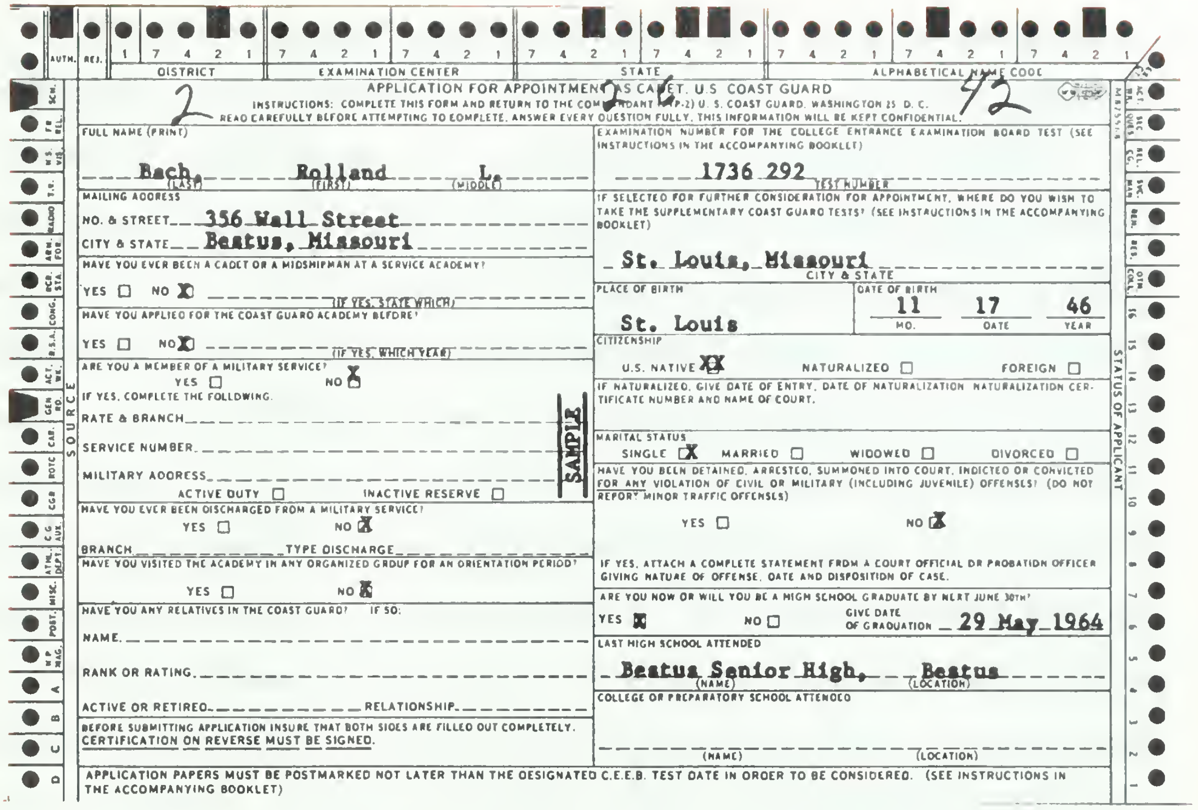
Fig. 24--Document-Term Matrix (top), Conventional Grouping Index Cards (middle), and Inverted Grouping Index Cards (bottom)

this:

a. Conventional Grouping. There is one index card or other type of record prepared for each document (or person, or place, or thing), as shown in figure 24 (middle). Then all the particular terms used to characterize the document are shown on the cards. This is also referred to as "term on item" grouping—"item" referring to the document. Searches are conducted by comparing the indexing terms named in the search request with those appearing on each index card and selecting those cards that match or fulfill this term requirement. This procedure is referred to as a serial search. Types of systems that use the conventional grouping and also the serial search are the edge notched cards, EAM (electrical accounting machine) punched cards, and microfilm or electronic computer systems.

b. Inverted Grouping. One card or other record is prepared for each indexing term appearing in the "dictionary" of terms for the system as shown in figure 24 (bottom). Index records are arranged by these indexing terms. This style of grouping is also called "item on term". Searching is conducted by selecting only those few term cards named in the search request and checking them to find what document numbers appear on each and every one of the cards. Examples of employment of the inverted grouping include the optical coincidence or "peek-a-boo" system and the Uniterm system; also EAM punched cards and electronic computer systems may use inverted grouping.

An example of an application for appointment as Cadet, U. S. Coast Guard is shown in figure 25. This card is a


AUTH.
REJ.
1 7 4 2 1
DISTRICT
7 4 2 1 7 4 2 1
EXAMINATION CENTER
7 4 2 1 7 4 2 1
STATE
7 4 2 1 7 4 2 1 7 4 2 1
ALPHABETICAL NAME CODE
SCH.
FR REL.
N.S. VIS.
T.V.
RADIO
ARM. FOR.
RCR. STA.
CONG.
B.S.A.
ACT. WK.
GEN RQ.
CAR.
ROTC
CGR
C.G. AUX.
ATHL. DEPT.
MISC.
POST.
N.P. MAG.
A
B
C
D
SOURCE
ACT. RR.
SEC. QUES.
REL. CG.
SVC. MAN.
REM.
RES.
OTH. COLL.
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
STATUS OF APPLICANT
SAMPLE

2

26

42

APPLICATION FOR APPOINTMENT AS CADET, U.S. COAST GUARD

INSTRUCTIONS: COMPLETE THIS FORM AND RETURN TO THE COMMANDANT (P-2) U. S. COAST GUARD, WASHINGTON 25 D. C.
READ CAREFULLY BEFORE ATTEMPTING TO COMPLETE. ANSWER EVERY QUESTION FULLY. THIS INFORMATION WILL BE KEPT CONFIDENTIAL.

FULL NAME (PRINT)
Bach, (LAST) Rolland (FIRST) L. (MIDDLE)

MAILING ADDRESS
NO. & STREET 356 Wall Street
CITY & STATE Beatus, Missouri

HAVE YOU EVER BEEN A CADET OR A MIDSHIPMAN AT A SERVICE ACADEMY?
YES ☐ NO ☒ (IF YES, STATE WHICH)

HAVE YOU APPLIED FOR THE COAST GUARD ACADEMY BEFORE?
YES ☐ NO ☒ (IF YES, WHICH YEAR)

ARE YOU A MEMBER OF A MILITARY SERVICE?
YES ☐ NO ☒
IF YES, COMPLETE THE FOLLOWING.
RATE & BRANCH
SERVICE NUMBER
MILITARY ADDRESS
ACTIVE DUTY ☐ INACTIVE RESERVE ☐

HAVE YOU EVER BEEN DISCHARGED FROM A MILITARY SERVICE?
YES ☐ NO ☒
BRANCH TYPE DISCHARGE

HAVE YOU VISITED THE ACADEMY IN ANY ORGANIZED GROUP FOR AN ORIENTATION PERIOD?
YES ☐ NO ☒

HAVE YOU ANY RELATIVES IN THE COAST GUARD? IF SO:
NAME
RANK OR RATING
ACTIVE OR RETIRED RELATIONSHIP

BEFORE SUBMITTING APPLICATION INSURE THAT BOTH SIDES ARE FILLED OUT COMPLETELY.
CERTIFICATION ON REVERSE MUST BE SIGNED.

EXAMINATION NUMBER FOR THE COLLEGE ENTRANCE EXAMINATION BOARD TEST (SEE INSTRUCTIONS IN THE ACCOMPANYING BOOKLET)
1736 292 TEST NUMBER

IF SELECTED FOR FURTHER CONSIDERATION FOR APPOINTMENT, WHERE DO YOU WISH TO TAKE THE SUPPLEMENTARY COAST GUARD TESTS? (SEE INSTRUCTIONS IN THE ACCOMPANYING BOOKLET)
St. Louis, Missouri CITY & STATE

PLACE OF BIRTH
St. Louis

DATE OF BIRTH
11 (MO.) 17 (DATE) 46 (YEAR)

CITIZENSHIP
U.S. NATIVE ☒ NATURALIZED ☐ FOREIGN ☐

IF NATURALIZED, GIVE DATE OF ENTRY, DATE OF NATURALIZATION NATURALIZATION CERTIFICATE NUMBER AND NAME OF COURT.

MARITAL STATUS
SINGLE ☒ MARRIED ☐ WIDOWED ☐ DIVORCED ☐

HAVE YOU BEEN DETAINED, ARRESTED, SUMMONED INTO COURT, INDICTED OR CONVICTED FOR ANY VIOLATION OF CIVIL OR MILITARY (INCLUDING JUVENILE) OFFENSES? (DO NOT REPORT MINOR TRAFFIC OFFENSES)
YES ☐ NO ☒

IF YES, ATTACH A COMPLETE STATEMENT FROM A COURT OFFICIAL OR PROBATION OFFICER GIVING NATURE OF OFFENSE, DATE AND DISPOSITION OF CASE.

ARE YOU NOW OR WILL YOU BE A HIGH SCHOOL GRADUATE BY NEXT JUNE 30TH?
YES ☒ NO ☐ GIVE DATE OF GRADUATION 29 May 1964

LAST HIGH SCHOOL ATTENDED
Beatus Senior High, (NAME) Beatus (LOCATION)

COLLEGE OR PREPARATORY SCHOOL ATTENDED
(NAME) (LOCATION)

APPLICATION PAPERS MUST BE POSTMARKED NOT LATER THAN THE DESIGNATED C.E.E.B. TEST DATE IN ORDER TO BE CONSIDERED. (SEE INSTRUCTIONS IN THE ACCOMPANYING BOOKLET)

Fig. 25--Sample Cadet Application

utilization of the conventional or term on item grouping. It is also an example of an edge notched card system. The applicant will fill in the form with the requested information and then Coast Guard personnel will encode some of this data in the border of the card by means of a punch which extends the hole already present in the border all the way to the edge so that a notch results at that location. Information which can be stored with notches in this manner include: the applicant's source of knowledge about the academy, the district, examination center, state, alphabetical name code, and other pertinent data.

The notches along the top of the sample card indicate that this individual is authorized to take the examination,

is in the second Coast Guard district, has code state number 26 (Missouri), and Alphabetical Name Code 42. A search through a file of these cards for individuals possessing certain characteristics is conducted using a steel needle similar to an icepick. If the searcher wished to determine which of the applicants were from Missouri, he would first observe that 3 notches in the "state" area of the border control this characteristic. He would stick his needle through the 2 and all those cards notched would fall out when the deck was lifted by the needle. Picking up the fallout, the searcher would place the needle through the 4 and lift again. A subsequent lifting through the 2 would allow to fall free all those applications from Missouri. Similar searches could be conducted to find other applicants (items) possessing certain characteristics (terms).

An example of the second type of grouping--inverted or item on term--is shown in figure 26. The illustrative card is a part of the Information Retrieval system employed by the Officer Personnel Branch of the Office of Personnel at Coast Guard Headquarters. It is called the Termatrex system by the manufacturer and is also known as the optical coincidence or peek-a-boo system. Each plastic card measures 9 1/2 x 11 inches and is assigned one characteristic term. On the card there are positions to correspond with as many as 10,000 individuals. Every Coast Guard Officer has a location on this card. The card is identified as OCBM 1030. OCBM stands for Officer and Billet Classification Manual and looking in

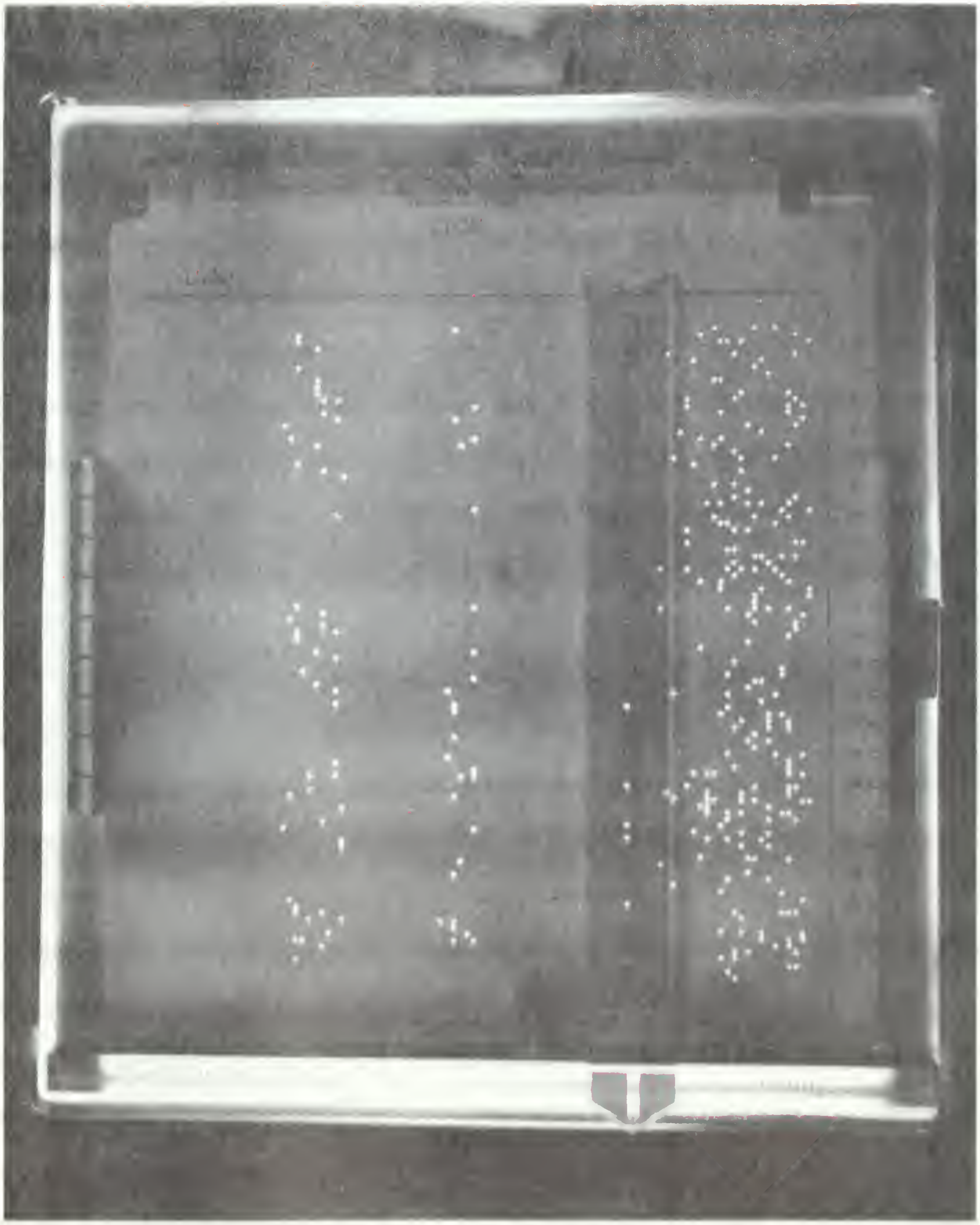


Fig. 26--Term Card

that publication under number 1030 will reveal that each hole represents someone who has been a military personnel officer at a unit or district office. Absence of a hole indicates that the officer to whom that "address" belongs does not possess the characteristic. The "address" is identified by placing a movable plastic device atop the card and lining it up with the "address". Two numbers are then read along the left or ordinate and two more are read along the abscissa on the device. On the left numbers go from 00 to 99; along the abscissa they range from 00 to 99. Therefore, possible addresses go from 0000 to 9999. These are assigned to individuals arbitrarily (customarily chronologically) by the operators of the system.

The complete system is pictured in figure 27. The cards and cardholder are shown at the left of the operator. The cards have a scale of 100 numbers from 00 to 99 printed along a colored strip at the top of the card. There is also a tab giving the exact number of a particular card. There are one hundred locations for tabs and ten different colored strips and so the file can contain 1000 cards. Further extensions could be made to the file by adding notches along the right hand side of the cards.

Posted on the wall can be seen the index relating colors, numbers, and terms. The operator's right hand rests on the manual input machine. It is with this device that the holes are made precisely in the plastic cards. On the far right is the reader equipment. Cards are selected from the cardholder in accordance with the search orders and these are

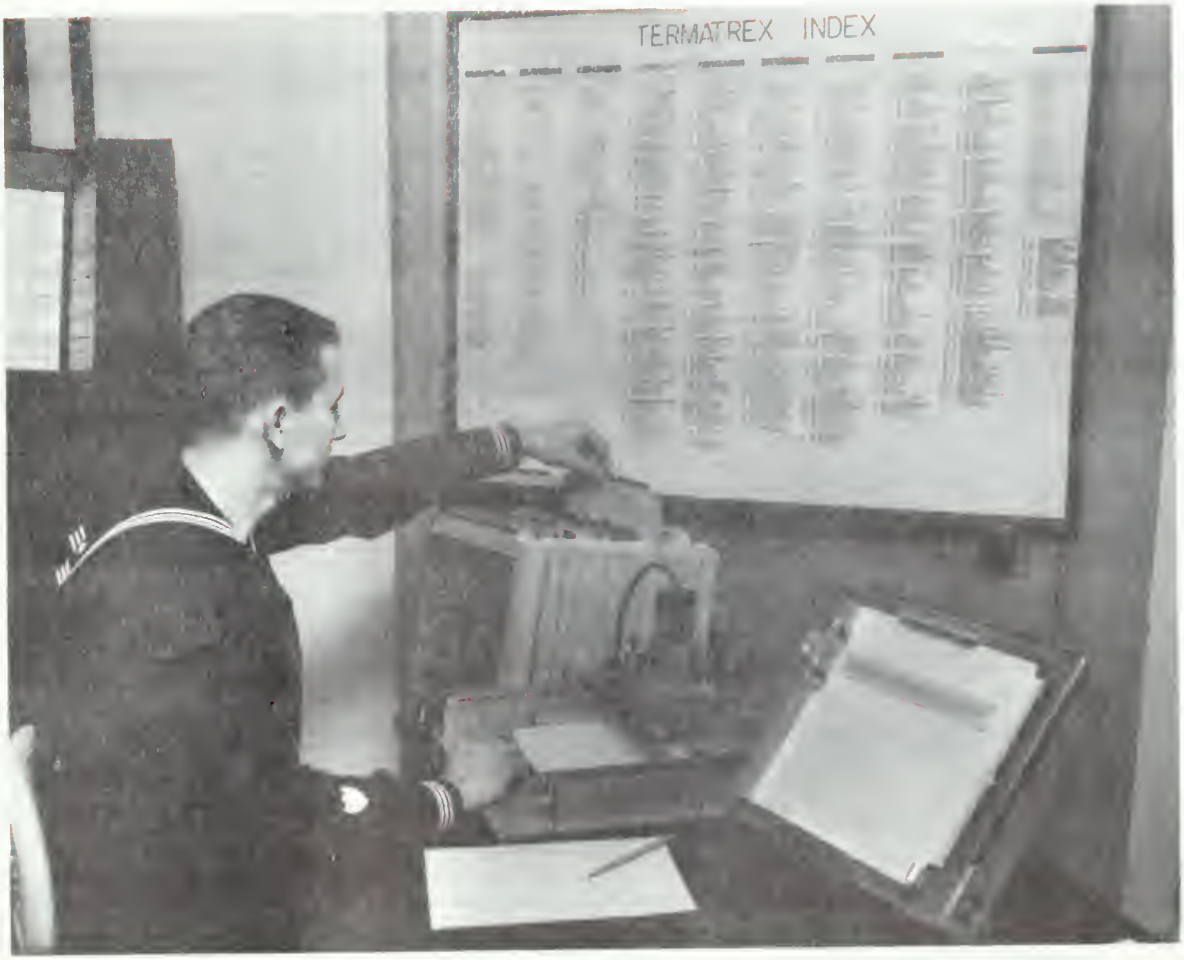
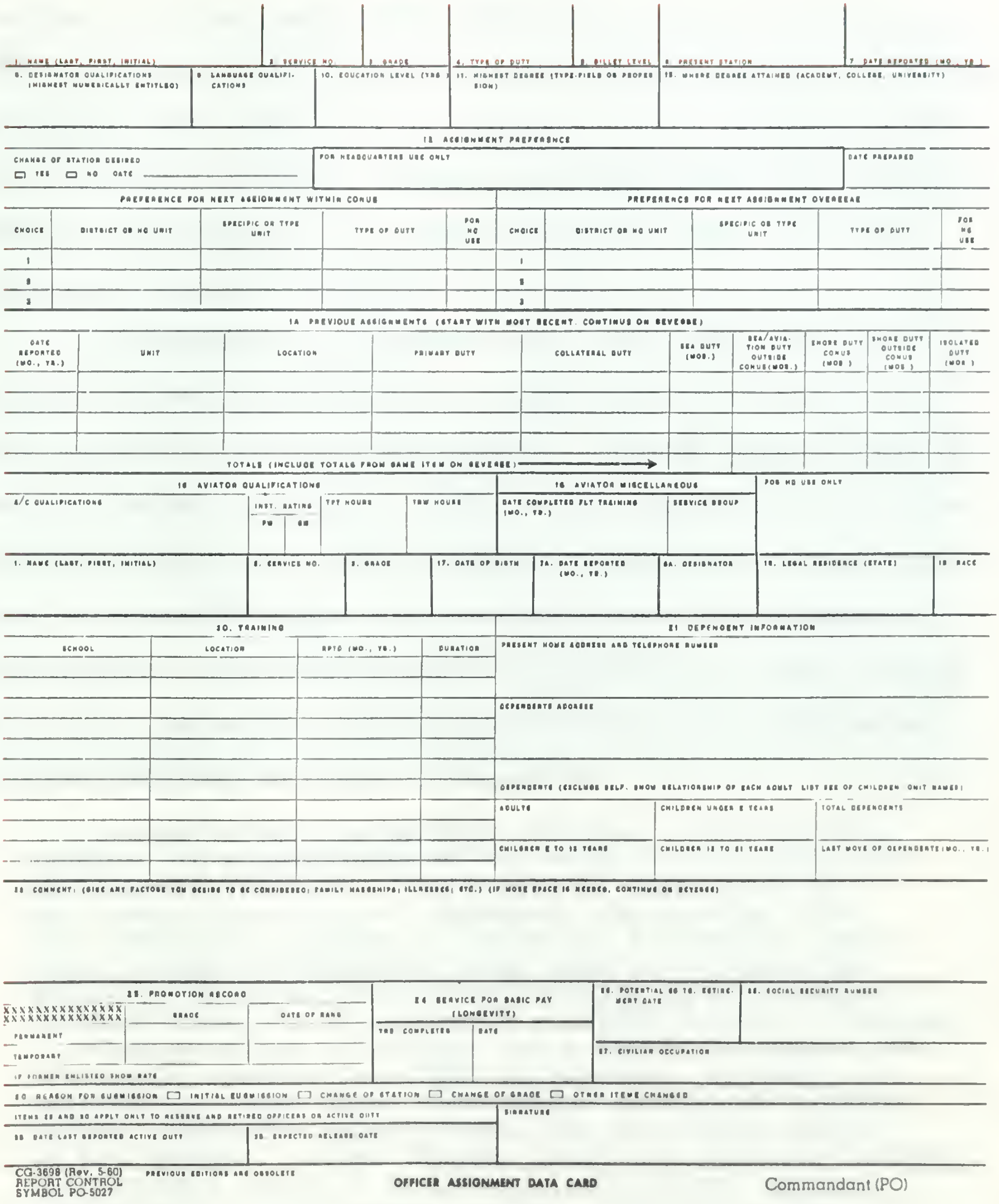


Fig. 27--Personnel Information Retrieval System

placed one on top the other on the face of the reader. Light will continue to shine through in those "addresses" where a hole appears on each and every card. The scale can then be positioned to read the numbers of those officers whose characteristics satisfy the parameters of the search.

Another example of conventional grouping is the Officer Assignment Data Card shown in figure 28. Most of the information on this card is repetitious and has been filed in the officer's personal service record or in his memory and had to be retrieved by the individual officer each time he submitted



1. NAME (LAST, FIRST, INITIAL)
2. SERVICE NO.
3. GRADE
4. TYPE OF DUTY
5. BILLET LEVEL
6. PRESENT STATION
7. DATE REPORTED (MO., YR.)
8. DESIGNATOR QUALIFICATIONS (HIGHEST NUMERICALLY ENTITLED)
9. LANGUAGE QUALIFICATIONS
10. EDUCATION LEVEL (YRS.)
11. HIGHEST DEGREE (TYPE-FIELD OR PROFESSION)
12. WHERE DEGREE ATTAINED (ACADEMY, COLLEGE, UNIVERSITY)

13. ASSIGNMENT PREFERENCE

CHANGE OF STATION DESIRED
☐ YES ☐ NO DATE ____________

FOR HEADQUARTERS USE ONLY

DATE PREPARED

PREFERENCE FOR NEXT ASSIGNMENT WITHIN CONUS

CHOICE	DISTRICT OR HQ UNIT	SPECIFIC OR TYPE UNIT	TYPE OF DUTY	FOR HQ USE
1				
2				
3				

PREFERENCE FOR NEXT ASSIGNMENT OVERSEAS

CHOICE	DISTRICT OR HQ UNIT	SPECIFIC OR TYPE UNIT	TYPE OF DUTY	FOR HQ USE
1				
2				
3				

14. PREVIOUS ASSIGNMENTS (START WITH MOST RECENT. CONTINUE ON REVERSE)

DATE REPORTED (MO., YR.)	UNIT	LOCATION	PRIMARY DUTY	COLLATERAL DUTY	SEA DUTY (MOS.)	SEA/AVIATION DUTY OUTSIDE CONUS (MOS.)	SHORE DUTY CONUS (MOS.)	SHORE DUTY OUTSIDE CONUS (MOS.)	ISOLATED DUTY (MOS.)
TOTALS (INCLUDE TOTALS FROM SAME ITEM ON REVERSE) →									

15. AVIATOR QUALIFICATIONS
A/C QUALIFICATIONS
INST. RATING: PW / SM
TPT HOURS
TRW HOURS

16. AVIATOR MISCELLANEOUS
DATE COMPLETED FLT TRAINING (MO., YR.)
SERVICE GROUP

FOR HQ USE ONLY

1. NAME (LAST, FIRST, INITIAL)
2. SERVICE NO.
3. GRADE
17. DATE OF BIRTH
7A. DATE REPORTED (MO., YR.)
8A. DESIGNATOR
18. LEGAL RESIDENCE (STATE)
19. RACE

20. TRAINING

SCHOOL	LOCATION	RPTD (MO., YR.)	DURATION

21. DEPENDENT INFORMATION
PRESENT HOME ADDRESS AND TELEPHONE NUMBER
DEPENDENTS ADDRESS
DEPENDENTS (EXCLUDE SELF. SHOW RELATIONSHIP OF EACH ADULT. LIST SEX OF CHILDREN. OMIT NAMES)
ADULTS
CHILDREN UNDER 5 YEARS
TOTAL DEPENDENTS
CHILDREN 5 TO 12 YEARS
CHILDREN 12 TO 21 YEARS
LAST MOVE OF DEPENDENTS (MO., YR.)

22. COMMENT: (GIVE ANY FACTORS YOU DESIRE TO BE CONSIDERED; FAMILY HARDSHIPS; ILLNESSES; ETC.) (IF MORE SPACE IS NEEDED, CONTINUE ON REVERSE)

23. PROMOTION RECORD

XXXXXXXXXXXXXX XXXXXXXXXXXXXX	GRADE	DATE OF RANK
PERMANENT		
TEMPORARY		

IF FORMER ENLISTED SHOW RATE

24. SERVICE FOR BASIC PAY (LONGEVITY)
YRS. COMPLETED
DATE

25. POTENTIAL 30 YR. RETIREMENT DATE
26. SOCIAL SECURITY NUMBER
27. CIVILIAN OCCUPATION

30. REASON FOR SUBMISSION ☐ INITIAL SUBMISSION ☐ CHANGE OF STATION ☐ CHANGE OF GRADE ☐ OTHER ITEMS CHANGED

ITEMS 28 AND 29 APPLY ONLY TO RESERVE AND RETIRED OFFICERS ON ACTIVE DUTY
28. DATE LAST REPORTED ACTIVE DUTY
29. EXPECTED RELEASE DATE

SIGNATURE

CG-3698 (Rev. 5-60)
REPORT CONTROL
SYMBOL PO-5027
PREVIOUS EDITIONS ARE OBSOLETE

OFFICER ASSIGNMENT DATA CARD

Commandant (PO)

Fig. 28--Officer Assignment Data Card

the form. In the future this information will be stowed in 1301 disk file of the computer complex at Headquarters. Officer Assignment Data Cards will be printed by the computer and then mailed to the individual officer for verification and updating. Computer preparation of the card is but one phase of a new Integrated Personnel Accounting System.

A variation on indexing occurs with the AMVER (Atlantic Merchant VEssel Report System). Input data is in the form of term-on-item or conventional grouping. Output data is item-on-term or inverted grouping. AMVER is the Coast Guard operation in New York that uses a 305 computer to maintain current positions of about 800 ships a day as they cross the Atlantic. Ship captains volunteer pertinent information by radio message and punched cards are prepared for inserting the information into the computer as shown in figure 29.

> Seconds after the message arrives, it is manually checked for authenticity of the vessel's call sign and anticipated position. The report is then given to a card punch operator who translates the message into the computer's language by indenting a standard punch-card. After verification, this card is fed into the computer, which stores the information in its fabulous "memory" until it is needed in a SURPIC (Surface Picture).
>
> When an alert is sounded and a SURPIC is needed, it takes only seconds for AMVER to respond. Quickly, an experienced Coast Guard electronics specialist sitting at the computer's console types out an interrogation to the machine. A few minutes later the computer answers. Its response comes in an automatically typed message giving data on all vessels within a certain radius of the vessel or plane in need of emergency aid. In 13 standardized columns, the computer lists the name of each vessel, her call sign, latitude and longitude, date and time, course, speed, radio watch schedule, availability of surface radar, doctor aboard, radio telephone availability, destination, and estimated time of arrival. If the computer finds there are no vessels within the initial SURPIC requested, usually a 100-mile

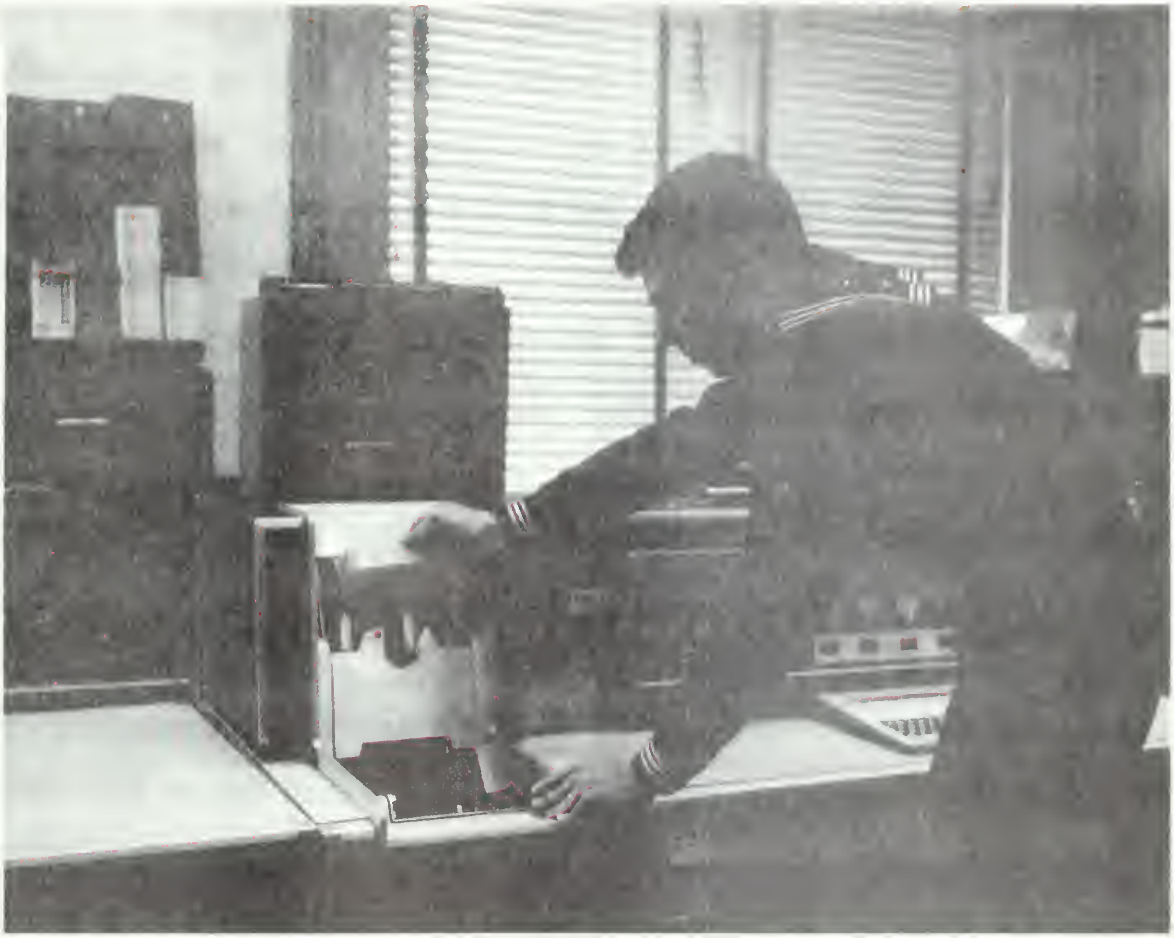


Fig. 29---AMVER Input

radius, a second interrogation is made to include ships within a 150- or 200-mile radius of the point of interest---the ship or plane in distress.[1]

Another Coast Guard Information Retrieval system is in the offing. The Office of Merchant Marine Safety (MMS) has determined that many of its print and record files should be relocated at a Federal Records Center. Space at Headquarters

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[1] Paul Van Wicklen, "They Plot For Safety's Sake," Proceedings Of The Merchant Marine Council, U. S. Coast Guard, Vol. 20, No. 6 (Washington: U. S. Government Printing Office, June 1963), p. 101.

has been calculated to be worth about $17 a square foot per month while at the Records Center space is available for about $3 per square foot per month. So it is quite likely that a microfilm or other system will be programmed soon for Headquarters MMS use.

Only a few specific types of Information Retrieval apparatus have been mentioned. There are a wide variety in use by business and industry: combined peek-a-boo and microfilm systems, combined microfilm and electronic computer systems, special photo storage devices, electronic display devices, and others. Common to all, however, are the indices and groupings set forth in this discussion. So also will they be to any Coast Guard systems for years to come. One day, information may be available on any subject from a speaking computer. One has already been developed to respond to audio requests for stock quotations.

CHAPTER VII

SUMMARY AND RECOMMENDATIONS

This study of Coast Guard plans and programs coupled with an analysis of what has been done by other agencies indicates that significant progress has been made by Coast Guard Management in using computers in the areas of Command Control, Operations Research, PERT and CPM, Logistics Management, and Information Retrieval. In fact, in some aspects of Operations Research, the Coast Guard may be in the forefront of development and application.

As a consequence of observing the march of the Coast Guard into the computer age, certain next steps recommend themselves:

1. A Pacific Ocean version of AMVER.

2. Ordnance, hull, mechanical, and electrical COSALs for all ships.

3. An advanced Command Control information system compatible with the Navy's.

4. Development of a system to determine when equipment replacement is more economical than repair at all levels of operation.

5. Encouragement of "in house" undertaking of Operations Research projects by the organizational elements

involved.

6. Familiarization of all Coast Guard managers with the basic principles of PERT and CPM.

7. Continuation of the war against routine paper to help control the Information Retrieval problem.

APPENDIX

GLOSSARY OF ACRONYMS AND OTHER ABBREVIATIONS

ADP, Automatic Data Processing

ALMC, Army Logistics Management Center

AMVER, Atlantic Merchant VEssel Report

ASO, Aviation Supply Office

ASW, AntiSubmarine Warfare

CIC, Combat Information Center

COSAL, Coordinated Shipboard Allowance List

CPM, Critical Path Method

DOD, Department of Defense

DSA, Defense Supply Agency

EAM, Electrical Accounting Machine

EDP, Electronic Data Processing

IBM, International Business Machines

LOGSIM-WC, Logistics Simulation-Wholesale, Computer Assisted

LORAN, Long Range Aid to Navigation

MILSTAAD, MILitary STandard Activity Address Directory

MILSTAMP, MILitary Standard Transportation and Movement Procedures

MILSTRAP, MILitary Standard Transaction, Reporting, and Accounting Procedures

MILSTRIP, MILitary STandard Requisitioning and Issuing Procedure

NAVCOSSACT, Naval Command Systems Support Activity

NTDS, Navy Tactical Data System

OR, Operations Research

PERT, Program Evaluation Review Technique

RAMAC, Random Access Method of Accounting and Control

RFQ, Request for Quotation

SAR, Search And Rescue

SECNAV, Secretary of the Navy

SNITS, Stock Number Identification Tables

STAGE, Simulation of Total Atomic Global Exchange

TAC, Transportation Account Code

TCMD, Transportation Control and Movement Document

UMIPS, Uniform Material Issue Priority System

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